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AUGUST, 1836.

Practical and Theoretical Mechanics.

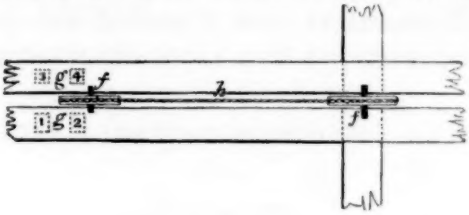
Experiments on the resistance of sand to motion through tubes, with especial reference to its use in the blasting of rocks, made at Fort Adams, Newport harbour, under the direction of Col. Totten. By Lieut. T. S. Brown, of the Corps of Engineers.

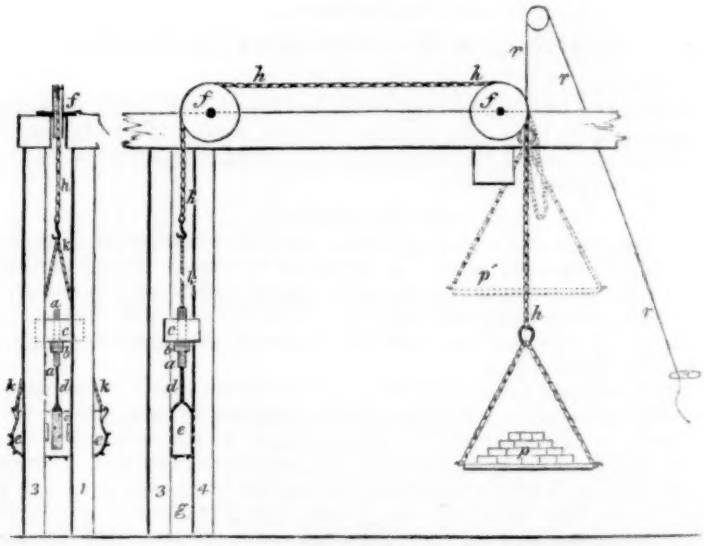
(continued from p. 8.)

For the purpose of examining further the degree and nature of the resistance offered by sand when it is attempted to force it through a tube by direct pressure, the following apparatus was arranged, after a few preliminary trials, which had given some idea of the power it would be necessary to apply. A side and end view, and a plan of the apparatus are given in the cut on the next page.

The strong cast composition tube, *a*, about fifteen inches in length, which contained the sand, was held in a vertical position by being passed through the block, *c*. The pressure was always applied to the bottom, and the collar, *b*, cast upon the tube, prevented its being forced upwards. The block *c*, was secured in its place by being let into the four posts, 1, 2, 3, 4, passing from the floor to the ceiling. These four posts formed a very stable frame work, and between each pair, the space, *g*, permitted the sliding board, *e*, to move freely up and down, and secured the proper direction to the pressing force. For the sake of distinctness this space, *g*, has been represented wider on the sketch, and the sliding board, *e*, thicker, than they actually were. The pressure was applied by means of a movable piston within the tube, connected by means of the iron rod, *d*, with the sliding board, *e*. This sliding board was attached, by means of the chains, *k*, *k*, *h*, *h*, *h*, passing over the cast iron pullies, *f*, *f*, to the platform, *p*. Of course any weight placed on this platform communicated a corresponding pressure upwards to the piston within the tube. The chain *h*, *h*, was of the best

Peru iron;* the wire was about $\frac{1}{8}$ an inch in diameter, and the chain had been proved with 9 tons dead weight. The pulleys, *f*, *f*, were about a foot in diameter; and their axles were of wrought iron an inch and a half in diameter. When a dead weight was to be applied, the platform was loaded in the position, *p*, but if a violent shock was to be produced, the platform was held in the position, *p'*, by means of the cord, *r*, *r*, *r*, until it had received the proposed load; the cord, *r*, *r*, *r*, being then suddenly cast loose, permitted the loaded platform to fall freely by its gravity, until it had straightened the chain, when it was either entirely arrested by the resistance of the sand in the tube, or it forced its way to the floor in consequence of the yielding of the sand, or of the fracture of some part of the apparatus.





There were other minor details which it is not necessary to particularize. The fixtures were not brought to the degree of strength just stated until after many trials, and the repeated failure of nearly every part of the apparatus; and, as will be seen, a limit was soon attained, beyond which the experiments, even with this degree of strength, could not be carried. The weights used were bricks. The piston was so arranged as to move without friction when the tube was empty, and at the same time to prevent the escape of the sand when the tube was charged. Trials were made with sand poured loosely into the tube, and with sand carefully packed. The packing

* *Peru*, Clinton county, New York. The iron from this locality possesses a remarkable degree of tenacity.

was performed by means of a small sharp stick which was worked up and down in the sand as it was slowly poured in. This method was found to be the best, and is the one always used at Fort Adams, in charging drill holes for sand blasting. The sand used was dry and free from dust, and from all particles which would not pass through a hole $\frac{1}{14}$th of an inch in diameter.

A preliminary series of experiments was tried, the results of which will not be given, as they were all subsequently repeated in a more careful and accurate manner.

In the second series, a tube of tin, fifteen inches long, having an interior diameter of $1\frac{1}{4}$ inches, was used instead of the cast composition tube, *a*, above described, and a $3\frac{1}{2}$ inch bolt-rope instead of the chain, *h*, *h*, *h*. The following table indicates a portion of the results obtained.

TABLE I.

No. of the Experiment.	Number of inches of sand in the tube. — Packed.	Number of inches of sand in the tube. — Unpacked.	Weight which it was necessary to place on the platform in order to force the sand from the tube.	REMARKS.
	Inches.	Inches.	Pounds.	
36		2	310	
37	2		350	
38		3	260	
39	3		360	
40	3		760	
41		4	2166	
42	4		2540	
43	4			Experiment lost.
44	4		2150	
45	5			With 2100 lbs. the piston was not moved.
46	9			With 1900 lbs. the piston was not moved.

Observations on Table I. The tube was of the kind called double tin, 15 inches long, and $1\frac{1}{4}$ inches in diameter, folded at the seam, and strongly soldered. The piston was just inserted into the bottom of the tube, and the weights given in the fourth column, were those which were necessary to force it quite through the tube, with the sand before it. In the experiment No. 46, where 9 inches of packed sand were tried, after a weight of 1900 pounds had been placed on the platform, without producing any effect, an effort was made to drive the sand from the tube by forcing up the sliding board, *e*, with a lever. In this operation the tube was bent, and split at the soldering, but the sand was not forced out. It was soon ascertained that very great weights would have to be used when the depth of the sand was equal to, or greater than four times the diameter of the tube, and that the process would be tedious; it was accordingly resolved to abandon the use of dead weights, and employ the momentum of falling bodies. Previously to making these trials, a glass tube $\frac{3}{4}$ths. of an inch in diameter, was procured and experimented upon. It admitted six inches of sand to be forced out of it, but with 8 inches of sand well packed, it burst when a dead weight of 550 pounds was applied.

TABLE II.

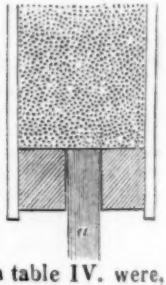
No. of the experiment.	No. of inches of sand in the tube. — Packed.	Weight with which the platform was loaded.	Distance through which the platform fell with the foregoing weight.		Distance through which the piston was forced by the foregoing power.	REMARKS.
	inches.	pounds.	feet.	inches		
47	5	920		10	none.	In these experiments the rope stretched so as to permit the platform to touch the floor before producing the full effect.
48	"	1120	2	0	do.	
49	"	1320	2	"	do.	
50	"	1320	3	"	thro'the tube	
51	6	1320	3	"	none.	Trial defective.
52	"	1630	3	"	none.	The rope was broken, trial defective
53	"	1630	3	5	thro'the tube	
54	7	1630	3	0	none.	The tube was split.
55	"	1630	3	"	$\frac{1}{4}$ of an inch.	
56	"	2030	3	"	$\frac{1}{2}$ of an inch.	The apparatus was broken, and the tube split.
57	"	1630	3	5	none.	Apparatus broken.
58	"	1630	3	4	$\frac{1}{4}$ of an inch.	
59	"	1930	2	6	$\frac{1}{4}$ of an inch.	
60	"	2030	3	0	$\frac{1}{8}$ of an inch.	Broke one of the beams supporting the pullies, *f*, *f*, and parted a $3\frac{1}{4}$ inch bolt rope.
61	"	2030	3	4	$\frac{1}{4}$ of an inch.	The rope was broken and the tube split at the soldering.
62	"	2030	4	0		Split the tube and forced out the sand in consequence.
63	"	2030	4	0	$\frac{1}{2}$ an inch	Parted a $3\frac{7}{8}$ inch white hemp rope.

Observations on Table II. The tube and rope were the same as described in observations on table I. The experiment No. 61, the top of the sand was made even with the top of the tube before the experiment was begun, by pushing up the piston until only so much space was left above it, as it was intended the sand should occupy. This rule was observed in all the subsequent experiments. This table shows that it required a weight of 1320 pounds, falling 3 feet, to force 5 inches of dry sand out of a tube $1\frac{1}{4}$ inches in diameter, and 1630 pounds, falling 3 feet 5 inches, to force out 6 inches of sand. Experiments, 60, 61, 62, and 63, showed that the apparatus in its then state could not sustain the force necessary to expel 7 inches of sand, and accordingly these experiments were suspended until a cast brass tube could be procured, and an iron chain be fitted instead of the rope. Other measures were also adopted for strengthening the apparatus. While these arrangements were making, a series of experiments were tried with a conical plug above the piston, as in the annexed sketch. The height of the cone was 3 inches, and its base equal to the area of the top of the piston. The details of these experiments it is deemed unnecessary to give. Their general result was, that within the limits tried, greater resistances were obtained when the cone was used than when it was omitted.

TABLE III.

No. of the experiment.	No. of inches of sand in the tube. Packed.	No. of inches of sand in the tube. Unpacked.	Weight with which the platform was loaded.	Space through which the loaded platform was allowed to fall.		Distance through which the piston was forced by the foregoing power.	REMARKS.
	in.	in.	lbs	feet.	in.		
87	7		1375	3	10	$\frac{1}{8}$ of an inch	
88	7		1670	3	11	$\frac{1}{4}$ of an inch	Broke a beam over head; and on taking up the floor for the purpose of putting up new props, it was found that three of the floor joists were ruined by the severity of the previous shocks. An iron axle-tree, $1\frac{1}{2}$ inches in diameter, of one of the pillars, *f*, over head, was broken off.
89	7		1880	3	10	$\frac{1}{4}$ of an inch	Broke the axle of one of the pulleys over head. The beams supporting these pulleys were brought nearer together, and iron trunnion plates were placed under each axle to prevent its being forced into the wood.
90	7		2030	3		$\frac{1}{4}$ of an inch	Broke the rope *k*, *k*, connecting the chain with the sliding board, *s*, under the piston. A chain was substituted in the place of this rope, and the apparatus thus made to conform in all respects, with the description which has been given of it.
91	7		2030	3	6	$\frac{1}{2}$ of an inch	
92	7		2286	3	11	Piston forced thro' the tube.	In this and all other cases where the piston was forced through the tube, a quantity of fine dust, apparrently arising from the pulverization of a part of the sand, collected on the sides of the tube and at the top of the piston.
93	8		2286	3	9	$\frac{1}{4}$ of an inch	
94	"		2490	3		$\frac{1}{4}$ of an inch	Broke a large iron hook at the tube end of the large chain.
95	"		2490	3		1-16 "	Broke the large chain in four places.
96	"		2490	3	9	$\frac{1}{4}$ of an inch	
97	"		2644	3		$\frac{1}{8}$ of an inch	Broke one of the hooks connecting the chain, *k*, *k*, with the sliding piece, *e*.
98	"		2644	3		none	Broke the large chain. The apparatus could not, without considerable trouble and expense, be made to sustain the force necessary to expel 8 inches of packed sand, and the further pursuit of this inquiry was therefore abandoned.
104		7	361	3	8	Piston forced thro	
105		8	361	3	3	$2\frac{3}{8}$ inches.	
106		9	615	3	10	Pn. forced through	
107		10	615	3	9	none	
108		10	870	3	10	Pn. forced through	
109		11	870	3	8	$\frac{5}{8}$ of an inch	
110		11	1122	3	3	1 inch.	
111		11	1375	3	4	2 inches.	The interior diameter of the tube was now increased to 1 7-16 in inches, with which all the remaining experiments were made.
113		11	1630	3	10	Pn. forced through.	
115		12	1880	3	3	$\frac{1}{8}$ of an inch	Broke the chain.
118		12	2136	2	3	$\frac{1}{2}$ of an inch	Broke the chain.
120		12	2136	3	3	$\frac{1}{2}$ of an inch	Broke the chain. This chain being much strained & worn by previous shocks a new one was procured.
121		12	2136	3		$\frac{3}{4}$ of an inch	Broke the chain.
122		12	2136	3	6	Pn. forced through	
124		13	2136	3	9	$1\frac{3}{4}$ inches.	

Observations on Table III. The tube was of brass, cast about one-fourth of an inch thick, the interior diameter being one and one-fourth inches as far as experiment No. 111, after which it was increased to one and seven-sixteenth inches. A chain, capable of supporting nine tons, was substituted for the rope, *h*, *h*, *h*., and after experiment No. 90, a strong chain was employed in lieu of the rope, *k*, *k*. The apparatus was strengthened in a variety of ways to enable it to resist the great shocks it was subjected to. It appears from this table, that to expel seven inches of dry packed sand from a tube one and one-fourth inches in diameter, it was necessary to employ a weight of 2286 pounds falling through a space of three feet eleven inches. A weight of 2644 pounds falling three feet, was insufficient to force from the same tube eight inches of sand. Sand poured loosely into the tube, without being packed, offered much less resistance. Seven inches of loose sand was expelled by a weight of 361 pounds falling three feet eight inches; nine inches by a weight of 615 pounds, falling three feet nine inches; and ten inches by a weight of 870 pounds falling three feet ten inches. Eleven inches in a tube of one and seven-sixteenth inches bore, was expelled by 1630 pounds, falling three feet ten inches; twelve inches, by 2136 pounds, falling three feet six inches; and 2136 pounds, falling three feet nine inches, did not drive out thirteen inches of loose sand. The strength of the apparatus did not admit of carrying these trials further in this way, and it was resolved to use gun-powder; but in the meantime to determine the resistance which would be offered by the sand to the entrance of iron rods of much less diameter than the bore of the tube, the following experiments were made. Rods of one-fourth, one-half, and three-fourths of an inch diameter were used. The tube being one and seven-sixteenths inches in diameter, a wooden piston having a hole in its centre, just large enough to admit the rod *a*, in the manner indicated by the annexed sketch, was placed in it, and the rod being entered into the piston, the sand was placed above it as usual. With this apparatus, the experiments contained in table IV. were, among others, tried.



Observations on Table IV. The resistance opposed by the sand to the entrance of a rod of smaller diameter than the tube, was very great, and increased with the size of the rod. A weight of 2033 pounds was required to force a $\frac{1}{4}$ inch rod through 8 inches of sand. With 12 inches of sand, a weight of 3150 pounds was required to force the same rod, sharpened, $2\frac{1}{2}$ inches into the tube. Sharpening the $\frac{1}{4}$ inch rod, seemed rather to increase than to diminish the resistance. A half inch rod was forced through 8 inches of sand, by 870 pounds falling 4 feet. With 13 inches of sand, a $\frac{1}{2}$ inch rod was forced only $1\frac{3}{4}$ inches, by a weight of 1880 pounds falling 3 feet 6 inches. A rod $\frac{3}{4}$ of an inch in diameter, was forced through 8 inches of sand by 1120 pounds, falling 3 feet 10 inches; and the same rod was forced through 13 inches of sand by 2136 pounds, falling 3 feet 3 inches. In all cases the sand immediately before and around the rods, was crushed to a fine powder.

Trials with Gun Powder.

166. A musket barrel, of three-fourths of an inch bore, was charged with two inches of powder and thirteen inches of packed sand, there being

neither wad nor plug between the sand and the powder. On firing, the barrel was burst, but the sand was not driven out.

TABLE IV.

No. of the experiment.	No. of inches of sand. Packed.	Dead weight applied.	Falling weight.	Distance through which the loaded platform was allowed to fall.		Distance which the iron rod was forced into the sand, by the foregoing power.	REMARKS.
	in.	lbs.	lbs.	feet.	in.	inches.	
Iron rod $\frac{1}{4}$ of an inch in diameter.							
133	8	615				$\frac{1}{4}$ of an inch.	
134	"	1150				1 inch.	
135	"	1630				$1\frac{1}{2}$ "	
136	"	2033				thro' the sand.	
137	12	615				3-16 of an in.	
138	"	1150				$\frac{1}{2}$ "	
139	"	1630				1 inch.	
140	"	2136				$1\frac{1}{2}$ inches.	
141	"	2480				?	Rod bent and broken.
142	"	615				3-16 of an in.	In these trials the end of the rod was sharpened.
144	"	1630				7-8ths. "	
146	"	2390				$1\frac{3}{4}$ inches.	
148	"	3000				$2\frac{1}{4}$ "	
149	"	3150				$2\frac{1}{2}$ "	
150	8		360	3	4	2 "	
151	"		615	3	4	thro' the sand.	
Rod $\frac{1}{2}$ an inch in diameter.							
152	8		360	3	6	$1\frac{1}{2}$ inches.	
153	"		490	4		$1\frac{3}{4}$ inches.	
154	"		615	4		$1\frac{3}{4}$ inches.	In this and every other instance a mass of finely pulverized sand was found at the head of the rod.
155	"		870	4		thro' the sand	The sand around the rod was pulverized to a fine powder.
157	13		1120	3	3	1 7-8 inches.	The rod was bent below the tube.
158	"		1375	3	3	$\frac{1}{2}$ an inch.	
159	"		1880	3	6	$1\frac{3}{4}$ inches.	Bent the rod double in two places below the tube.
Rod $\frac{3}{4}$ of an inch in diameter.							
160	8		870	3	10	$\frac{3}{4}$ of an inch.	
161	"		1120	3	10	thro' the tube	The sand around the rod crushed to a fine powder.
162	13		1120	3	9	7-8 of an inch.	The pulverized sand at the head of the rod as usual.
163	"		1375	3	6	1 inch.	The chain was broken.
164	"		1880	3	6	$1\frac{1}{2}$ inches.	
165	"		2136	3	3	thro' thesand	

167 & 168. A brass blunderbuss barrel of three-fourths of an inch bore, was charged with one inch of powder and ten inches of packed sand, a

wooden plug being placed between the powder and sand. On firing, the plug was split, and all the sand driven out, but the pieces of the plug remained in the barrel, which was apparently uninjured. The same barrel burst with one inch of powder and ten inches of packed sand, with a conical wooden plug between the sand and the powder.

169. A pistol barrel of nine-sixteenths of an inch bore, burst with one inch of powder and eight inches of packed sand, without wad or plug.

170. An old musket barrel of three-fourths of an inch bore, was loaded with three-fourths of an inch of powder and five inches of packed sand, without wad or plug. On firing, the barrel was burst, but the sand was not driven out.

172. A piece of musket barrel, taken from near the muzzle, and open at both ends, was charged at one end, with five and a half inches of brick dust, hard rammed, and at the other, with five and a half inches of sand, well packed, with one inch of powder between them, a priming hole being bored to communicate the fire. The explosion of the powder burst the barrel, but neither the sand nor the brick dust was driven out.

177 to 184. A pistol barrel made of twisted iron, and of great strength, the bore being eleven-sixteenths of an inch, was fired with three-fourths of an inch of powder, and the following loads of sand, each one, with, and without, a wad, viz: three inches, four inches, five inches, and six inches. In all these trials the sand was driven out without causing the barrel to burst.

185. The same pistol barrel was loaded with one inch of powder, and eight and one-fourth inches of sand, with a conical plug between the sand and the powder. On firing, the sand was forced out.

186. The same barrel was charged with one inch of powder and eight and one-fourth inches of sand, without wad or plug. On firing, the sand was driven out, and the barrel was burst.

In order, if possible, to determine a limit to the resistance opposed by sand, it was resolved to make use of a twenty-four pound cannon. It was thought not improbable, that by the use of clean dry sand, which is generally obtained in the vicinity of the sea coast batteries, a ready method would be discovered of effectually destroying heavy guns, an object which is occasionally of great importance. Application was therefore made to the ordnance department for permission to experiment with an old pattern twenty-four pounder, laying at Fort Adams, which permission was very liberally and readily granted. The length of the bore of this piece was about nine feet, and the diameter of the bore $5\frac{82}{100}$ inches. It was first fired in a horizontal position, with eight pounds of powder and one foot of sand, afterwards with the same quantity of powder and two feet of sand, again with the same quantity of powder and three feet of sand, and so on, the depth of the sand constantly increasing by one foot, until the bore was full. The gun was then placed in a vertical position, and loaded with the same quantity of powder, and filled up to the muzzle with sand, well packed, without wad or plug. It was afterwards charged in a similar manner, a cone of wood being interposed between the powder and the sand. In these two cases the fire was communicated to the charge by means of a priming tube, passing down through the sand from the muzzle of the gun. Afterwards the gun was charged in the same manner, and fired by means of the vent. A better quality of powder was then used, and the quantity was increased to sixteen pounds. The gun was several times fired with this charge, the bore being filled up to the muzzle with sand well packed. In every in-

stance the sand was forced out without apparent injury to the gun. It appeared, therefore, that the resistance of the sand, though very great, was not sufficient to burst a twenty-four pound cannon.

The most probable explanation of the foregoing phenomena, appears to be, that whenever direct pressure is applied, the angular and irregular shaped fragments composing the sand, immediately form themselves into a natural arch, supported against the sides of the tube. The annexed sketch indicates the manner in which this may take place. In every instance where the sand was violently forced from the tube, the sides of it were found to be lined with a quantity of fine dust, and a mass of pulverized sand was generally found at the head of the piston A. The inside of the tube was abraded or scratched, particularly at that part, a short distance above the piston, against which the *arch*, or more strictly, the *inverted dome* of sand, may be supposed to have abutted. The dust found on the sides of the tube was always of a blueish colour, which was attributed to the intermixture of a small portion of metallic oxide derived from the brass. Some experiments which were made went to show that it was very important that the sand should be perfectly dry. The injurious effect of moisture may be explained by supposing that it impedes the free motion of the particles among themselves, and prevents their promptly assuming the arch form; it cements the sand into a mass, which is expelled from the tube as a solid body would be. In the case of the twenty-four pounder, it appears that the force necessary to burst the gun, was greater than that required to reduce sand to an impalpable powder, that is, to crush and destroy the materials of which the arch of sand was composed. It is probable that coarse emery, from its extreme hardness, would oppose a resistance sufficient to burst a cannon, but an opportunity has not offered to make the trial.

The experience at Fort Adams, proves that the resistance offered by sand is quite sufficient for blasting rocks, and the advantages attending its use, are, that it is much less troublesome than the usual mode, and that it is perfectly safe. To ensure success, the space left above the powder should have a length of ten or twelve times as great as the diameter of the hole. To communicate fire to the powder, a slip of paper is rolled into a tube about three-sixteenths of an inch in diameter. This priming tube is secured by being tied round in two places with thread, and one end is made a little larger than the other, so that any required length may be obtained by joining several together. The charge of powder being in its place, the priming tube is inserted and filled, it is then pressed against one side of the hole, and the sand is slowly poured in. A slender stick of hard-wood is rapidly worked up and down in the sand as it falls to the bottom, and thus every part becomes well packed. By this mode of operating there is, of course, no danger of communicating fire to the powder in the act of loading, an accident very liable to happen in blasting in the common way. The safest and most convenient method of firing the blast is by means of a small slip of paper which has been dipped in a solution of salt-petre, and dried.

It was intended to make examinations on other points connected with the phenomena observed by M. Burnand, but the requisite leisure has not been at command. The subject merits further investigation with a view to making useful practical applications of some of the remarkable properties which sand is found to possess.

On the manufacture of Military Projectiles, translated from the French of F. I. Chumann, Chief d'escadron d'artillerie, &c. &c. By ALFRED MORDECAI, *Captain United States Ordnance Department.*

(CONTINUED FROM p. 17)

Of the Lathe.

The lathe for turning cores consists generally of four stakes driven into the ground, and surmounted by a kind of rectangular frame of wood; the two pieces of this frame which stand in a direction perpendicular to the spindle of the core, may be called the transoms; their distance apart varies with the diameter of the core. The transom which is on the right hand of the workman, as he faces the lathe, has a copper gudgeon box to receive that part of the spindle which is next to the smaller base of the swell: this base should rest against the gudgeon when the spindle is on the lathe. The other transom is furnished with a square piece of iron, which forms the nut of a screw terminating in a point, and intended to support the end of the shaft, in which there is a small conical hole to receive the end of the screw. A crank, with a rectangular hole in it, is adjusted to the upper part of the spindle which it serves to turn. A weight suspended to an iron hook, prevents the spindle from leaving the gudgeon box.

Of the preparation of Sand Cores.

Cores of sand are formed on a nucleus of clay. The spindle is first placed in the lathe, turning the screw until the small base of the swell touches the gudgeon, so that the swell is between the two transoms. After having put in place the double hook to which the weight is suspended, the workman rolls a rope of straw around the spindle, making three or four turns. This rope is kept in its place by wooden pins, which are burnt during the process of drying and casting. He then applies several layers of clay, until the nucleus has the dimensions of the pattern. Before the nucleus is quite dry, several holes are made in it, in order that the sand may adhere more readily.

The model of the core is a copper box, divided into two parts by a plane through the centre, perpendicular to the axis of the eye. Its interior form and dimensions are those of the core, allowing a few points in excess for shrinking, if the projectile is of a large caliber. This shrinking cannot exceed three points in twelve inch shells; it is almost insensible in small ones.

One of the hemispheres of the box is terminated by a plane, and consequently remains open, when the shell is to have a culot; in the contrary case when the shell is to be concentric, that hemisphere is pierced at the pole, with a hole through which the sand is introduced, and which is afterwards closed by a cap. The other hemisphere, that which is first filled, has a hole of the diameter of the core of the eye, and is firmly fixed in a piece of wood which is let into a tripod stand.

The two parts of the box are connected by a groove, and fastened together by a ring which embraces the upper hemisphere, and which is confined by two hooks, acting at the extremities of a diameter.

To fill the lower hemisphere for the purpose of moulding the core, first place the spindle furnished with the nucleus, and with the core of the eye, which should be made of clay with great accuracy, calibered, and finished dry *on the lathe.* The swell of the spindle should rest against a small plate of iron fixed to the stand, so that the distance from the swell to the

core shall be constant, and equal to the distance from the traverse to the mould of the shell, added to the thickness of the metal. That thickness, measured at the eye of the shell, is then subject to no variation, if the traverses, the flasks, and the spindles, are perfectly alike, and if the latter correspond with the spindles of the models. In ramming the sand into the first hemisphere, the workmen should be careful to withdraw the spindle a little, and to be certain that it rests against the plate of iron above mentioned; for the ramming of the sand below the nucleus of the core tends to raise the spindle.

The rammers used are curved, and may be made either of iron or wood. When the box is perfectly full, the sand is leveled with a rule, then smoothed and compressed with a trowel, if the shell is to have a culot: if not, it is only necessary to fill the box by ramming closely, and to stop the hole with sand, which is afterwards compressed by applying the cap. To withdraw the core from the mould, the upper hemisphere of the box is taken off, whilst the lower remains fixed in the wood. The end of the spindle is inserted in a hole made in the stand; the core being then perfectly free may be trimmed at the seam, or circle of junction, which always leaves a kind of bur that it is necessary to remove.

The core when trimmed, is dipped into clayey water, made more glutinous by the addition of horse dung: very fine powdered coal is also added to the water: this coat of coal dust prevents the sand from adhering to the metal. If the mixture is not sufficiently adhesive, the powdered coal does not stick to the core, but becomes detached and floats on the metal, which causes large wrinkles about the eye of the shell. After this, the core is thoroughly dried; the least quantity of water remaining in it would either make the casting fail, or would produce great defects about the eye. It is always better to bake the core too much than too little, and failures are generally attributable to the neglect of this precaution. The purer the sand the more easily it is dried; but it is necessary to use sand containing a little clay, in order that the core may have the requisite consistence.

Common salt has the property of causing sand to harden very readily; a solution of salt, enables us, therefore, to use very loose sand, which is a great advantage; but cores made in this manner must be used immediately, for salt, being very hygrometric, would, in twenty-four hours, absorb water enough to spoil the casting. This method therefore can be used only under particular circumstances. Generally speaking, the cores should be exposed to a red heat, unless salt be used: they may be dried on the trunnel head without expense.

Of the preparation of Cores of Clay.

The nucleus is made in the manner before described, taking care to insert straw in the groove of the spindle when it is solid. It is dried at the doors of the furnace, avoiding immediate exposure to a red heat, and thus burning the straw. When the nucleus is dried, it is fixed better on the spindle, and prevented from slipping towards the swell, by means of a bit of slate introduced into one of the holes made in the spindle. After another layer of clay has been added to the nucleus, a second piece of slate is inserted in the hole at the end of the spindle. The core is then again dried, replaced on the lathe, and thus the operation is continued until it has received the requisite dimensions, calculated according to the dimensions of the projectile, and the contraction of the clay by a red heat. The number of layers given to each core, and consequently, the number of times it is dried,

varies with the caliber of the shell. At Hayange, five successive layers were formerly added to the nucleus for twelve inch shells, and two only for six inch or eight inch howitzes. At the furnaces of the Ardennes, the cores even for twelve inch shells were made in three layers. The process must necessarily differ according to the quality of the clay, its power of retaining moisture, and the degree of heat requisite for drying it. Although the dimensions of the last coat of clay given to all the cores, are regulated by the same pattern, calculated on the dimensions of the cavity and the contraction of the clay, the finished cores have never the same dimensions; they have not only lost their sphericity, but some have become too large, others too small. They therefore undergo another operation, called *dressing*. They are first examined by the aid of three instruments, the ring gauge, the half circle, which is a section of the core, and the caliber plate for the eye. The parts where they are too large are then scraped with a knife, and clay is added where the dimensions are too small. This operation is performed by hand, and there is consequently no certainty of accuracy. It is essential that the last coat of clay given on the lathe should be very thin, in order that the defects of form, which evidently result from the great contraction of clay by heat, may take place in the last layer but one, which ought to be so thick that the core before being dried, should have, at least, the dimensions it is to have when finished and dried. Instead of performing the operation of dressing by hand, it might be done on the lathe, by substituting for the pattern board a piece of iron, or tempered steel, and scouring the core with a paste of clay mixed with sand. The core of the eye should be turned when dry, and reduced with a chisel to its exact dimensions. This remark applies equally to cores of sand, and to those of clay. When the core has been dressed, it is blackened with coal powder, and again dried.

If the inspector, in verifying the cores with the gauge intended for that purpose, finds any that are too small, he should break them at once: because cores after having been dried and blackened cannot be increased in size. The workmen, who often judge erroneously of their own interest, and who moreover pay little regard to that of others, would secretly use these cores without alteration, with the hope, doubtless unfounded, that the defect of a projectile of which the metal should be too thick, would not be perceived in the inspections.

It is not so in the case of cores which are too large; they may be corrected by scraping and blackening them a second time. Generally speaking, the cores are blackened after having been dressed, and they are again dried.

The mere description of these different processes, shows that whatever degree of care is bestowed on cores made of clay, it is impossible, in making a great number, to have them exactly alike. It is therefore much better to make them of sand.

Of the preparation of the Mould.

To prepare the mould the workman places the upper hemisphere of the model on a board furnished with two battens, which enables him to seize it more easily underneath. He then inserts the spindle into the hole of the traverse, and places the *drag* on the moulding board. By turning the flask he makes sure that it touches the board, and that it rests against the swell of the spindle, which is an essential point. If the flask did not touch the board the projectile would be flattened, the polar diameter becoming too small: if on the other hand, the flask rested on the board, and the traverse did

not touch the swell of the spindle, the metal of the projectile would be too thin near the eye. These defects are but too often met with, because the flasks are warped out of shape. After the flasks have been properly placed, the gate is fixed; that is to say, if the shell is to be cast with the eye downwards; if the reverse, the vertical part of the gate would be placed in the sand of the cope. The workman supports with one hand the foot of the gate, which he adjusts on one side against the model, and on the other against the vertical part of the gate, around which he immediately packs a little sand. As his assistant fills the flask the moulder compresses the sand, either with his hand, in the angles, or in the middle, with a wooden paddle. If he is forming the mould of a large shell, he places the ears, and when the sand has reached a proper height, he presses the sand against them with his thumb, and supports the rings until they are fixed. As soon as the flask is entirely filled and the sand has been well rammed, the workman removes the superfluous sand with a rule, forms a funnel about the upper part of the gate, and with a needle pierces the sand in several places, to make vents, particularly above the ears. He then turns the flask on another board, furnished also with battens, and called the *false bottom;* he removes the moulding board, places the other hemisphere of the model in its groove, and lays the second part of the flask on the first, by making the dowels enter their corresponding holes; he sprinkles powdered charcoal on the model and on the sand, to prevent the fresh sand from adhering to the first, and fills the flask as he had before done, taking care to compress the sand a little more firmly if the projectile is to be cast with the eye uppermost. To remove the model the workman inserts a small bar of iron into the mortise of the spindle, slips under this bar a piece of wood, such as a paddle for instance, which resting on the sides of the flask, acts as a wedge under the bar, so that the model pressed against the sand, may not be displaced when the flask is removed. Turning the flask then on its side, he strikes a few blows with his paddle on the model, and detaches it, after having withdrawn the iron bar which confined it. He then places the model on a level board, fills the hole left by the spindle, and smooths the mould with the *mushroom* and the *sage leaf;* two small iron tools, which are used only for this purpose, and the forms of which are sufficiently indicated by their names.

The moulder uses the same method to remove the first hemisphere of the model: he withdraws the ears; lays the mould on a tripod stand without a top; places the core, measuring with a T the distance at which it should be from the equatorial diameter of the shell, and fixes it firmly either by inserting a key into the mortise of the spindle, or by driving nails between the stem of the spindle and the sides of the hole in the traverse. Having done this, he again joins the flasks and presses them closely together, either with key bolts, if the flasks are of cast iron, or with small hooks attached to the wooden flasks.

It is evident that if the two flasks were not pressed together sufficiently, the projectile would have a thick seam, which would be injurious to it, and it might also become too large in a polar direction. The latter cause added to the compression of the sand by the expansion and weight of the metal, often produces elongated projectiles. On the other hand they would be flattened, if in moulding, the flask rested only on the swell of the spindle, and left an interval between it and the moulding board. The flattening of a shell may also be occasioned by using too much sand to stop the hole of

the false spindle; it is therefore better to suppress the false spindle of the model for calibers of six or eight inches, as the flasks when filled with sand are still manageable.

To remove the model in that case, the two flasks are inverted together, a nail driven between the traverse and the spindle, and the hemisphere containing the eye is first removed.

Of casting and finishing hollow Projectiles.

The liquid metal should form a continuous stream, small at first, in order not to injure the mould. If the projectile is so large that the mould cannot be filled by a single ladle full, they should follow each other without interruption, and the contents of one should be poured into another, instead of being introduced immediately into the mould. The bottom of the ladle is of hammered iron, which the moulder covers with clay, with which he also lines the edge. He renews the lining at each casting, and dries it on the hot slag.

An assistant holding in one hand a piece of wood, and in the other a piercer, cleans the surface of the metal, and prevents the slag from running into the mould. It is necessary that the gases which are developed in the core should escape freely; if they do not immediately appear, either at the vents, or principally at the eye, where they ought to burn with a blueish flame, the assistant inserts his pierce in the groove of the spindle, and presents a piece of lighted wood, to set fire to the gases, and facilitate their escape. If the core has been badly dried, or if the sand of the mould is too wet, these gases are at first found in so great a quantity, that being unable to escape entirely, they prevent the metal from entering the mould; it then rises in the gate, and the casting fails. That accident may also happen if the metal is poured in too rapidly at first; without exactly rising, it sometimes receives from the same causes, a motion in the interior of the mould; in that case, little scales are formed on the projectile, which adhere but slightly to the mass of the metal, and which are easily detached with a hammer, particularly about the eye and the ears; this injures the shell and may become a cause of rejection.

A quarter of an hour after the casting, when the metal, though hard, is still quite hot, the upper flask is removed, and the gate detached with a hammer; the spindle of the core is then inserted in a winch and withdrawn. To draw out the spindles of sand cores, a greater effort is required than for those of clay, because the straw which envelopes them is more burnt in the latter, on account of the greater heat to which they are exposed in drying.

The bur which is formed about the eye is next removed with a rasp. This operation requires particular care, to prevent breaking the eye, which would almost always happen if it were rasped at too low a temperature, or if the bur were too thick; this occurs when the swell of the spindle of the core does not exactly fill the cavity formed by that of the model, the greater base of which is a little smaller than the orifice of the eye. The requisite dimensions are given to the eye by means of a six sided reamer, and they are verified by a gauge. The eyes, which from the inattention of the workman, are not sufficiently large, are afterwards reamed out when cold: a countersink in the form of a very obtuse truncated cone, serves to remove the sharp edge of the eye.

It is advisable to remove the projectiles out of the foundry while they are yet hot, in order to sprinkle water on them, and facilitate the removal

of the sand. But this sprinkling of water increases the contraction perceptibly: attention should therefore be paid to it, in determining the dimensions of the model.

When the projectile has become cold, it is handed over to the finisher who places it on a bench composed of two pieces that do not touch each other, between which it is secured by means of wedges. He breaks the core with a hook and a kind of chisel, turns the shell several times, to empty it entirely, and by means of a hammer and a rasp, removes the sand which still adheres to the surface. This sand adheres more strongly in proportion as it contains more clay; it is often necessary to chip the metal in order to remove the sand entirely. This facilitates oxidation, and injures the appearance as well as the quality of the projectile. We have indicated the method of preventing this defect, by mixing the sand with the dust of mineral coal, coke, or charcoal, and by wetting the projectiles immediately after they are cast. The seam and any roughness of the surface are removed by the chisel.

Projectiles which are of irregular dimensions should be always rejected, unless they can be ground to a proper form. Permission is sometimes given to dress with the chisel a certain number of these defective projectiles, which produces very bad results; especially if it be necessary to remove the metal on a large portion of the surface of the shell. Those which are carefully ground have a very handsome appearance; but, in common with those which are dressed with the chisel, they have the great fault of being liable to rust.

Of the manufacture of Shot.

Shot were formerly cast in iron moulds, called *shells*; they were afterwards hammered. It is about ten years since the casting of them in sand commenced: a great improvement, which however, is not yet definitively adopted.

The iron moulds consist of two equal parts, which are let into each other: each half is furnished with two handles. The gate, which is very wide at the mouth, is placed at the highest point; the plane of junction or rather the joint, is vertical at Hayange, and horizontal at some other founderies, as for instance at those of Niederbrunn.

The models for these moulds are made of copper, encased in wood to prevent their being altered by use. The inner surface of the copper serves to make a core of sand which forms the cavity of one half of the mould. As the exterior surface of the moulds may be left rough and uneven, they are cast uncovered; that is, the model is merely impressed in the sand, and removed without covering the hollow thus made, which is then filled with the liquid metal. In this way large objects, of which the under surface only is required to be exact, are generally cast. In this way it is evident that the joint of the mould is horizontal when it is cast. The interior of these moulds is not spherical. The vertical radius is smaller than the horizontal, which is that of the joint. The following differences are allowed, $3\frac{1}{2}$, 3, $2\frac{2}{3}$, $2\frac{1}{3}$, 2, $1\frac{2}{3}$ points, for the calibers of 24, 16, 12, 8, 6, 4, respectively. These data have been furnished by experience.

These moulds produce, therefore, spheroids flattened in the horizontal direction, perpendicular to the plane of junction. The shot obtained from them are consequently a little reinforced at the seam or bur occasioned by the joint, and it is necessary that they should be so; because that part re-

ceives under the hammer, a great number of blows which tends consequently to diminish this great circle and to increase those perpendicular to it.

In many founderies it is moreover customary to remove the bur with the rasp, when the shot have been heated for hammering; that operation, which is very bad, as we shall see, also requires that the projectiles should be larger at the seam when they leave the mould.

In casting shot, the two parts of the mould are joined together, after having been washed with muddy water. They are placed on a piece of cast iron furnished at the two extremities with two arms, which serve to hold the moulds, and by means of which they can be wedged together. It is to be observed that the gate should be vertical, and the handles turned outwards. They are connected in sets consisting generally of about twenty moulds.

The metal is dipped out from the crucible of the furnace with ladles, and is poured into the moulds in a regular stream, care being taken to skim it constantly.

Of casting Shot in Sand.

The moulds for shot are made of sand in a manner similar to those for howitzes. When this method of fabrication was first ordered in the department of the Moselle, in 1824, it was directed to roll the shot in an iron cylinder before hammering them. We had already made in this manner, in 1821, about fifty shot, which we showed to Lieut. Gen. Tyrlet, who thinking them very good, took several of them to show the committee of artillery.

Our experiments were varied in different ways. We used both the metal which furnishes brittle iron, and which is generally used for making projectiles, and the metal of tough iron, with which carriage flasks were then made; the shot were either rolled, or hammered, or else rolled first and then hammered.

The following are the conclusions which we have derived from these experiments:

1st. Shot first rolled and then hammered, are very superior to those which have undergone only one of these operations.

2nd. Hammering cannot be advantageously replaced by rolling; if we do not wish to adopt both of these operations, it is infinitely better to retain the former.

3rd. The ore of tough iron gives shot of a more even surface than the ore of brittle iron.

4th. The small cavities which often appear at the upper pole of a shot, occur as frequently with one of these kinds of ores as with the other.

It is to be remarked that the small cavities in question, and of which we have already spoken, are not found in all kinds of cast iron. There are founderies in which this defect is scarcely known; shot made of white metal are always free from them; but they have others still greater. We shall return to this subject in speaking of rolling, hammering, and inspecting shot.

Of Models for Shot.

The models of shot resemble those of hollow projectiles; but they have only one spindle, which is pierced at the upper end with a mortice to receive a small ruler, and is of use only for removing the model. If shot are to be only rolled, or to be hammered after rolling, the models should be

spherical, except that of the twenty-four pounder shot, because the weight of this projectile may compress the sand, and cause it to give way unless it is very firmly rammed.

The models of shot which are to be hammered without first rolling them, should be made a little full at the plane of juncture. For this purpose they are flattened in the contrary direction; if of a heavy caliber this flattening should commence at a considerable distance from the poles. The reasons for adopting this form have been already given.

We have often remarked that all projectiles undergo a slight depression along the seam, both above and below; this fact is probably connected with the phenomenon of the contraction of a fluid vein escaping from an orifice. It would follow that all the models ought to be a little full at the plane of junction; but it is not so, because the workman striking gently on the models to disengage them from the sand, cannot avoid enlarging the mould at the equatorial diameter: the small increase of diameter which results from this cause, compensates for the depression alluded to.

The form of the moulds in different cases, should therefore be governed by the reasons heretofore stated.

In turning the models they are at first made spherical; if necessary, they are afterwards flattened, according to a particular pattern cut out of sheet iron, which serves as a guide. These models should rather be made too large than two small, as we have before remarked, because they can be easily reduced, but cannot be enlarged. But with the same model and the same metal we may obtain larger or smaller shot, according to the manner of ramming the sand.

The foot of the gate ought to be thin and broad; the angles at the end which touches the model, should be a little chamfered, in order that the gate may be more easily detached.

Of Moulding and Casting Shot.

Several shot may be cast at one time in one flask, by arranging the moulds in two rows, between which is placed a principal gutter, running through the whole length, from which the metal passes into the moulds by small channels terminating at each mould.

For this purpose there are first placed on the moulding board, the model hemispheres without spindles, and the gates according to the arrangement they are to have. The moulder fills the flask, packing the sand as it is put in, smooths it, opens the mouth of the gate, makes five or six vents with a piercer two lines thick, and turns the flask on a *false bottom*. He afterwards puts in their places the other hemispheres furnished with spindles, sprinkles powdered charcoal on the model and on the sand to prevent the adhesion of the fresh sand, places the second part of the flask, taking care to fasten the hooks or bolts, and fills it, compressing the sand more closely than in the first flask, especially if the shot are of a large calibre.

To remove the model, the workman introduces small rulers in the mortises of the spindles, takes off the flask which he has last filled, lays it on its side, proceeds as has been directed for the shells, and joins the two flasks again, fastening the hooks or key bolts which secure them together: the mould is then finished.

The metal should be poured in more slowly in proportion as it is more liquid. The size of the gate ought to vary, indeed, with the degree of fluidity of the metal; but this is not practicable.

When the metal begins to become solid, the flask should be turned upside down. It has been observed that when this is not done, a cavity or at least a slight depression, is formed at the superior pole, which is prevented by upsetting the flasks. The bubble of gas which causes it, being thus driven back towards the centre, does not occasion so great a displacement of the centre of gravity, and the shot becomes more spherical. It is very important to seize the proper moment for turning the mould, which varies from one day to another, if the metal is not the same.

It is particularly this defect observed in shot cast in sand, and seldom in those cast in iron moulds, which has caused doubts as to the preferable method. The decision has been at length made in favour of the former, on account of the greater accuracy of dimensions and form in the shot thus made, and of the smoothness of their surface. We are of opinion that if shot cast in iron moulds, which are otherwise very imperfect, have not the defect we have just mentioned, it is to be chiefly attributed to the position of the gate, which is straight and terminates at the highest point of the mould. This arrangement could not be made for shot cast in sand moulds; the gate must necessarily be placed at the plane of junction, in order that the metal may run along the inner sides of the mould, without falling suddenly on the bottom, which would not fail to injure it. But the cause of the defect being known, we immediately see a radical remedy; instead of removing it at the expense of the density of the shot, it will be sufficient to make at the upper pole of the mould a very large vent, like a gate, to place the mould carefully in a horizontal position, to increase a little, if necessary, the height of the upper flask, in order that the liquid metal may be subjected to a greater pressure, and to pour in the metal very slowly towards the last. When the shot are cold they are trimmed: this operation is often performed with a hammer, and in a very rough manner, when the shot have been cast in iron moulds: a remedy is afterwards attempted, when they are hammered, by rasping them while hot, which is very faulty. It is important that the shot should be carefully trimmed with the chisel, especially if they are to be only rolled afterwards.

(TO BE CONTINUED IN OUR NEXT.)

Suggestions in regard to regulations for the safety of Steam Boilers. By A. C. JONES, *Engineer.*

In the law proposed during the last session of our Congress, for regulating steam vessels, I find that some very essential matters are entirely unnoticed; some of these I propose to pass in review. First. Nothing is said about having an additional safety valve to the boiler. This, however, is admitted to be a necessary appendage, as it is of importance that one of the valves should be secured by fixing a box or basket over it, to prevent it being overloaded. The regulation adopted abroad, for keeping the lock-up valve from adhering to its seat, namely, to examine it at stated times, is imperfect, as I have known valves to cement to the seat in a few hours from the time of examining them. The following simple arrangement would serve to keep the lock-up valve free. Suppose the valve to be loaded with a weight placed upon it; to the top of this weight a cord, or small chain, is attached, and passing through the cover of the box, is carried over a pulley and made fast to the cord connected with the valve, under the engineer's charge, and by which he raises it. It is evident that when the engineer

raises his valve, the other will be opened simultaneously, and consequently the lock-up valve will be prevented from cementing.

In the seventh section of the law referred to, directions are given how the engine shall be managed at stopping places. The method in common use for slacking the fire is to open the furnace doors, and nearly to close the damper. If it were entirely closed, the flame would come out at the furnace door. This method is, however, very defective. I have found by experience, that steam will be generated as fast for a limited time, under these circumstances, as if the fire was in active combustion. No cold air, or very little of it, enters the fire doors, for the simple reason that there is no outlet for it, and the active heat in the fuel will, therefore, keep the steam high, even when the engine is running. I have run a large engine with anthracite coal, which being fairly ignited, I have kept the damper closed for hours, the combustion being meantime maintained, the air passing through the crevices around the damper. The reasoning supported by the fact just stated, proves conclusively, that the generation of steam will not be *quickly* checked by the common methods of damping. To effect this purpose, the arrangement of the furnace should be such that the ash pit, or pan, could be closed so effectually as to prevent air passing through the grates. The damper and fire doors being then opened, the cold air passing over the surface of the fuel, will cool the boiler in its passage. The proposed regulations have omitted to establish any rules for cleaning the boilers. These, of course, would have to vary with circumstances, but should be laid down as carefully as possible. The proposed regulations will be productive of greater safety, by making engine builders pay more attention to the construction of the boilers. If the steam chimney of the Wm. Gibbons, or of the Ohio, had had stay bolts to connect the flue with the shell in that part above the roof of the boiler and rings, shown in the annexed cuts, enclosing and riveted to the flue, no collapse of the flue would have taken place. I suggested this arrangement to a boiler maker several years since, and his answer was "that the plan was good; but as long as the old method answered, there was no necessity for incurring additional expense."

Fig. 1

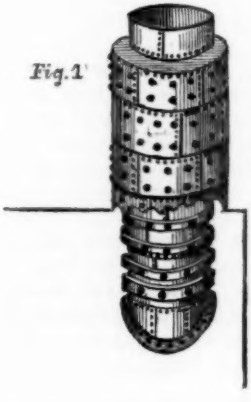


Fig. 1st, shows the steam chimney as strengthened by the stay bolts and rings.

Fig. 2.

Fig. 2nd. One of the rings, the internal projections, being in contact with the flue, with rivets passing through them.

Portsmouth, May 25th, 1836.

Further remarks, on suggestions, by Mr. Perkins, in regard to the Explosion of Steam Boilers. By a CORRESPONDENT.

In the June number of this Journal,* I commenced an examination of certain suggestions in regard to the explosion of steam boilers, by our countryman Mr. Perkins. The examination was made by the light of *direct experiments* by the Committee of the Franklin Institute, on the explosion of steam boilers. It was there shown that the following suggestions of Mr. Perkins are erroneous, viz: First, that the gradual increase of pressure within a steam boiler, cannot produce all the effects of the most violent explosions. Second, that the projection of water into hot and unsaturated steam, can produce highly elastic, or explosive steam.

I now propose to apply the experiments of the Committee above referred to, to test the further suggestions contained in the article under examination.

It has been seen in the preceding essay that Mr. Perkins assigns as one cause of explosion, that water gets too low in a boiler. Then according to him, the metal becoming heated forms unsaturated steam which rises, and water being thrown into it, is flashed into explosive steam.

In justice to the very direct experiments of the Committee on explosions, I ought to have inquired whether surcharged steam could exist in a boiler containing water. Whether such steam would not take up water and become, in a greater or less degree, saturated. But as the answer would have been favorable to the statement, that unsaturated steam might so exist, I passed on, taking the circumstances to be as stated by Mr. Perkins. The reader will, however, find this point fully settled in the answer to the fourth inquiry of the Committee.† A fire being made upon the top of a boiler, while the quantity of water within was kept at about 308° Fah., the steam became highly surcharged, so as to attain a temperature of 533° Fah. This surcharged steam remained above the water, which varied from three inches to .9 of an inch in depth, more than two hours, its pressure not rising above seven atmospheres; while saturated steam of the same temperature would have had a pressure of more than *sixty atmospheres*. These experiments stood a severe test, now to be described. Setting out with steam of 308½° Fah., the pressure of which is 5.2 atmospheres, if heat be applied to expand it as a gas, supposing no water to be taken up, the steam will have, by calculation upon the known rate of expansion, a pressure of 6.75 atmospheres.‡ As satisfactory a coincidence, with the pressure actually measured, and which is stated above, as could be desired.

Though this hot steam may exist in a boiler, there seems no occasion to guard against its remaining, or to look for a method to indicate its existence, since it is proved that the projection of water into it will diminish, not increase, its pressure.

I proceed next to examine the effect of water thrown upon hot metal, and it will be seen that Mr. Perkins is fully borne out, in assuming this as a source of *very great danger*; that he should, in fact, have looked entirely, to the heated metal itself, as the cause of explosion, and not to the surcharged steam which it may produce. The committee on explosions took the course, involving assuredly some personal danger, of making a di-

*See page 369, vol. XVII. † p. 73, vol. XVII. Jour. Frank. Inst.
‡ Ibid. p. 74.

rect experiment on this point.* The bottom of the experimental boiler being heated to a red heat, water was injected by the forcing pump, and the pressure obtained ascertained by a gauge. In every case the pressure rose very rapidly.

"In the last experiment, the glass window at the fire end of the boiler, blew out with a quick, sharp report, as loud as that of a musket; the fragments of glass, from a hole in the centre of the plate, were projected through a window, about three feet from the boiler, and could not be found. The number for twelve atmospheres is placed opposite to this experiment, as being an approximate result. In the act of observing the gauge, the glass window burst, and the mercury at once fell: the number of inches at which the mercury had certainly risen, and above which it was, by an undetermined quantity, not however very considerable, was noted, and from this the pressure given in the table is calculated. Here explosive steam is generated by the injection of water upon red hot iron, and in a time not exceeding one or two minutes at the most, the interval between the last stroke of the pump and the explosion, not having been sufficient to note the height of the gauge; the experimenter being at the pump, which was adjacent to the gauge."

The glass window referred to, we are elsewhere told, was three-eighths of an inch thick, and its dimensions were two and a half by one and three quarter inches.

Here then, by the injection of a limited quantity of water, which it is stated was not sufficient to cool the metal to the temperature at which it would have produced steam most rapidly, a bursting pressure of eleven atmospheres was rapidly produced.

Some experiments originally made by Klaproth, and repeated by Mr. Perkins, seemed to show that water thrown upon very hot metal, was so entirely repelled by it as to generate but little steam. Indeed, this has been regarded as a stumbling block in the way of the theory, which assigns to the hot metal so important a part, in producing explosions. It was this, probably, which led Mr. Perkins to abandon the idea that heated metal is the source of danger, in favour of the hot and unsaturated steam. It was the consideration of such results, that induced Mons. Arago† to say, that in order to complete this theory, which he attributes to Marestier, it must be shown why the water in a boiler acts differently when thrown upon hot metal from the small drops in the iron spoon, in Klaproth's experiments. The committee of the Franklin Institute, have not only proved the fact to be that explosive steam may be produced by throwing water on red hot metal, but have supplied an answer to the difficulty just referred to, by an elaborate series of experiments‡ on the vaporization of different quantities of water in metallic vessels of different materials, thicknesses, states of surface, &c. and have pointed out the influence of all these circumstances on the rapidity with which water is converted into steam. The effect of pressure in modifying the results was appreciated in their first experiment.

The direct experiment before referred to, being sufficient to meet Mr. Perkins' views, I pass on for the present, intending to recur to these other experiments, for information quite as important as the fact under review.

If then the water in a steam boiler should fall below its proper level, the portion of fire surface exposed without water, could become unduly heated as in the experiments of the committee. But how are we to find the water to be thrown upon the hot metal? Mr. Perkins answers this question, by

* Ibid, p. p. 14, 15. † Annuaire du bureau des Long. 1830, p. 191.
‡ Jour. Frank. Inst. vol. XVII. p. p. 90, 91, &c.

supposing the safety valve to be "suddenly raised, the water will [then] be relieved from the steam pressure," and rush up, and "that part of a boiler which has been raised in temperature, giving off its heat to the water so elevated, steam is generated in an instant, &c."

Is it the fact, as here asserted, that water when relieved from pressure, does rise ihto foam? Again, when that foam is thrown upon the sides of the boiler, does it generate more steam than is sufficient to compensate for the loss of steam which produced the diminution of pressure and thence the foaming?

When M. Arago wrote his essay on the explosion of steam boilers, he could not decide the first of these questions; he brought general analogy to bear in favour of the probability that this foaming was produced. The experiments of the committee on explosions have supplied, completely, the desired information. They examined the question in its bearing "upon the apparatus designed to show the level of the water within the boiler," and also upon the question now before the reader.*

"The first experiments on the effect of relieving water in ebullition from pressure were made in a glass boiler: here the fire was under the whole length of the boiler, which was a cylinder of fourteen and a quarter inches in length, and seven and a half inches in diameter. The steam within, being at a pressure of less than two atmospheres, by opening a cock at the end of the boiler, or the safety valve, also at the end, large bubbles were formed through the whole extent of the boiler.

The inquiry was prosecuted in the iron boiler already described, a distinct view of the interior being had through the glass windows placed in the heads. The greatest intensity of the fire was in front of the middle of the boiler, and extended through about one-third of its length: the part immediately near the flue, was next to this band in temperature. With this boiler experiments were made, which showed, that on making an opening in the boiler, even when the pressure did not exceed two atmospheres, a local foaming commenced at the point of escape, followed soon by a general foaming throughout the boiler, the more violent in proportion as the opening was increased. This small boiler was completely filled with foam by opening the safety valve, (nearly two-tenths of an inch in area) which was placed on the middle of the top, and the water violently discharged through the opening of the valve. The area of the valve bears to the horizontal section of the boiler, at the water line, the ratio of one to two thousand and fifty-five nearly. The boiler was half full of water in these experiments."

To show the extent to which this foaming may take place, I quote an experiment in point.

"The steam in the boiler being not higher than two atmospheres, the following experiment was made. The level of the water was reduced until it stood just below the lowest gauge-cock. On opening this cock, steam at first flowed out, then water and steam; on opening the second cock, in addition, water flowed freely from the lowest, which was above the hydrostatic level; the foaming within the boiler, which was produced by thus relieving the pressure, was distinctly seen through the glass windows. On opening the third cock, steam and water issued from the second, which was two inches above the water level; and on partially raising the safety valve, water flowed freely from the second cock. A further rise of the valve filled the boiler with foam, water flowed freely out of the third cock, more than three inches and three quarters above the water level, and finally through the opening of the safety valve itself. In these experiments, an opening of .03 of a square inch in area, the lowest cock, which, to the area of the water surface, was as one to thirteen thousand seven hundred, caused water and steam to issue through a cock, below which the water was known to be. A further opening of .03 of a square inch, making, with the first, .06 inch, or one six thousand eight hundred and fiftieth the area of the water surface, brought water from the lowest cock; a total opening of .09 inch, (one four thousand five hundred and sixty-seventh of the area of the water surface) brought water and steam from the middle

* Jour. Frank. Inst. vol. XVII. p. p. 8, 9, &c.

cock, indicating that the level of the water was nearly two inches higher than it really was.

A first apparatus, which was contrived for applying fusible plates to the boiler, suddenly opened an aperture of .95ths of an inch in diameter. Even at low pressures, the scalding contents of the boiler were violently discharged through this opening, against the roof of the experiment house."

But after all, will the steam produced by this foam coming in contact with the heated sides of a boiler, be greater in quantity than the escape steam which produces the foaming? M. Arago says, that in experiments which he made on the effect of opening a safety valve, the pressure was always diminished. But he remarks that the boilers on which he experimented had their full supply of water. His results do not therefore, decide the question. Indeed, the question being one of degree, is a difficult one. The Committee of the Franklin Institute endeavored to imitate the circumstances to be found in a boiler in which the water is low. Having allowed the water to waste, the bottom of the boiler above the water level became heated; openings of different sizes were made in succession, so as to produce different degrees of foaming. In every case an opening produced a diminished elasticity of steam.*

M. M. Tabareau and Rey of Lyons,† found a different result by surrounding a small high pressure boiler with flame, allowing the water to become low, then opening a large stop cock. The pressure was increased.

These results do not contradict each other, they show that an increase of pressure may or may not be produced, *according to the quantity of hot metal present.* No one would probably venture upon making an opening under circumstances in which it was a mere question of degree whether the boiler would burst or not. At the same time the experiments of the committee led us to look further for causes to produce explosion from heated metal, by a sudden access of water. The choking of a forcing pump and the sudden removal, by the action, of the pump of the obstruction, the sudden introduction of water when it has been found very low, without putting out the fires, are occurrences which would produce a certain result. The last is entirely within the control of the engineer. In connected boilers occupying the breadth of a boat, the careening of the boat will cause just such a state of things. If continued long enough it cannot fail to produce an explosion.

Wherever there is unduly heated metal there is danger, and that danger may be actually increased by making an opening into a boiler, is the inference from this examination. Before leaving this subject, and after differing in the former essay entirely from Mr. Perkins, I am so well pleased to find some part of his suggestions well founded, that I am disposed to dwell upon it, I propose to examine whether the danger of explosion from hot metal will probably increase with the temperature, or not.

Finding that drops of water are repelled from heated metal at quite moderate elevations of temperature, the result has hitherto been assumed, as applying to the case of a steam boiler, of which the metal is unduly heated. Reflection will show that this is not the case, the heated metal is cooled by the very act of generating steam. The rapidity of the supply of heat is also to be taken into account. If the metal is directly above the fire receiving heat, the result will be very different from what would take place, were the heat derived from conduction, through the medium of other heated

* See Jour. Inst. p. 14. †Ibid, p. 13.

parts of the boiler. The problem is in some sort indeterminate. This has been pointed out in the report of the committee on explosions, and experiments have been devised by using different modes of applying heat, to give an idea of the true state of the case.*

They began by showing the early development of a repulsion in the heated metal, tending to diminish the vaporization of water, taking place when the quantity of water is too small to cool down the metal, at a lower temperature in copper than in iron, in a clean surface of metal than in one which is oxidated. This repulsion, preventing the effect of the increased difference of temperature in the metal, and the water to be vaporized produces a maximum in the vaporizing power of the metal. The vaporizing power of different metals at their maximum is different, being greater in copper than in iron, nearly in the ratio of the conducting powers of the metals. An important practical conclusion where the heat of the metal is kept up, as the temperature of greatest vaporization lies below that of our high pressure engines.†

By increasing the water, from drops to as great a quantity as the bowls, used in the experiments, would contain, and varying the circumstances by communicating heat to the metal through oil, and through tin, the Committee proceeded to examine the question now before us. While the quantities of water were small, great regularity appeared in the results, permitting a calculation of the temperature of greatest vaporization from results below that temperature.‡ The general conclusions are stated briefly thus:§

1st. The vaporizing power of copper, when supplied with heat, by a bad conductor or circulator, such as oil, increases with great regularity as the temperature increases, up to a certain point, the water being supposed thrown upon the copper surface, in small quantities. Copper flues, heated by air passing through them, would be in this condition if left bare of water, and then suddenly wet. This holds with copper one-sixteenth of an inch thick, without indication that a limit will be attained by a much more considerable thickness. The temperature at which the metal will have the greatest vaporizing power, is about 570° Fah., or about 230° below redness, according to Daniell.

The law of vaporization of small quantities of water, by a given thickness of copper, is represented with singular closeness by an ellipse, of which the temperatures represent the abscissæ, and the times of vaporization the difference between a constant quantity and the ordinates.

2d. The same power in thin iron, .04 inch thick, increased regularly, and was at a maximum, probably, at 510°. With thicker metal the power increases more rapidly at the lower temperatures, and varies very little, comparatively, above 380°, with thicknesses exceeding one-eighth, and less than one-fourth of an inch; attaining a maximum at about 507° Fah., when the quantities are small; rising to 550°, and much above, as the quantity of water is increased relatively to the surface of the metal which is exposed. Quadrupling the quantity of water, the entire amount being still small, nearly tripled the time of vaporization at the maximum.

3d. When copper of one-sixteenth of an inch in thickness, was supplied with heat by melted tin, a worse conductor, and having a lower specific heat than copper itself, the time of vaporization, in a spherical bowl, of quantities varying from one-sixteenth to one-half of the entire capacity of the bowl, increased but three-fold, and the temperature of greatest evaporation was raised by 56°, or from 470° to 526°. When the bowl had half of the portion which was exposed to heat filled, the weight of the water was about one and one-tenth of that of the metal.

4th. The times of vaporization of different quantities of water, varying from one-eighth of an ounce to two ounces, in an iron bowl one-fourth of an inch thick, and supplied with heat by the tin bath, were sensibly, as the square roots of the quantities, at the temperatures of maximum vaporization for each quantity.

* Jour. Frank. Inst. vol. XVII. p. 152.
† Ibid. See p. p. 150, 151.
‡ Ibid. p. p. 152, 153, &c. and plates 5 and 6.
§ Ibid. p. p. 162–3.

These temperatures were raised from about 460° to 600°, by increasing the weight of water about sixteen times, indicating that considerable quantities of water, thrown upon heated metal, will be most rapidly vaporized when the metal is at least 200° below a red heat.

5th. While a red heat, visible in daylight, given to a metal, even when very thick, and supplied by heat from a glowing charcoal fire, does not prevent water, when thrown in considerable quantities, from cooling it down so as to vaporize the water very rapidly, it is much above the temperature at which the water thrown upon the metal will be most rapidly evaporated. Thus one ounce of water was vaporized in thirteen seconds, at about 550°, in a wrought iron bowl one-fourth of an inch thick, and required 115 seconds to vaporize in a cast iron bowl one-half an inch thick, at a red heat. Four ounces in the latter bowl vaporized in about 300 seconds, the bowl being red hot when it was introduced; and two ounces vaporized in thirty-four seconds at 600° Fah.

6th. The temperature of greatest vaporization, with a given thickness of metal, is lower in copper than in iron, the repulsive force being developed at a lower temperature. With equal thicknesses of iron and copper, the vaporizing power of the latter metal, at its maximum, was, with the oil bath, one-third greater than that of the former, and with the tin bath the power of copper .07 of an inch thick, was equal nearly, to that of iron, one-fourth of an inch thick, each being taken at its maximum of vaporization, for the different quantities of fluid employed. As the maxima for the iron are higher than those for the copper the advantage will be still greater in favor of copper when the two metals are at equal temperatures.

7th. The general effect of roughness of surface is to raise the temperature at which the maximum vaporization occurs, and to diminish the time of vaporization of a given quantity of water at an assumed temperature below the maximum.

8th. Though it has been shown that water thrown upon red hot metal is adequate to produce explosive steam, even when it does not cool the metal down to the temperature of most rapid vaporization, it is not the less true that metal more than two hundred degrees below a red heat, in the dark, is in the condition to produce even a more rapid vaporization of water thrown upon it, than when red hot.

We thus acquire a certainty of this remarkable fact, that a boiler may be in a more dangerous condition; (that is, in a condition more fit to produce *suddenly* highly elastic steam,) when below a red heat, from water thrown upon the metal, than even when the danger shows itself by the luminousness of the metal. Although, as we have seen, explosion may be produced at a red heat.

We are by all this plainly directed to the necessity for keeping up the supply of water in a boiler. A keen interest is excited as to the means of ascertaining this level. The necessity for methods of showing when the metal of the boiler becomes hot, before it has reached the point when it becomes dangerously so, is clearly proved. All these important practical matters the reader will find treated of, in the report from which I have drawn the materials of these essays.

But to return to the theory of Mr. Perkins. We have followed up two of his positions, and have now arrived at the third. "The *third* and less frequent kind, [of explosion] although most terrific, is undoubtedly caused by an explosive mixture having been formed in the boiler." This "third kind" I propose to examine by the same light which has enabled us to separate truth from error in the first and second. D.

Physical Science.

Communication of a formula for facilitating the reduction of observations of the solar eclipse of May 15th, 1836. By S. C. Walker.

TO THE COMMITTEE ON PUBLICATIONS.

Gentlemen: The formulæ communicated by me in the April number of the Journal, were intended for announcing the time of the principal phases

of the solar eclipse of May 15. By applying a correction derived from observations made under a known meridian, they may be used for determining the longitude of places at which it was observed, when not too far distant from Philadelphia, for which place alone, they are strictly correct. The error of the middle time of the eclipse, as deduced from the formula, amounts to one second of time for New York and Albany, to two seconds for Baltimore and Washington, and to eight seconds for Boston and the University of Virginia. By applying to the middle time by the formula, a correction depending upon the first and second powers of the difference of longitude from Philadelphia, results may be obtained, in which the greatest variation from a rigorous computation for the above places, will in no instance exceed 0.6 sec., and in which the average discrepancy will not exceed 0.4 sec. In the former communication it was omitted to mention that l, denotes the *geocentric* latitude of the place for which the computation is made.

Retaining the same notation and constants as before, we have for the resulting longitude of the place of observation from Greenwich, +East—West

$$\lambda = A+B+C$$

Where,

$$A = \lambda' + x + \left\{M - M'\right\} - [8.8557]\left\{D - D'\right\}$$

$$B = [4.9781]\left\{5\text{ h. }0\text{m }40\text{s.} + A\right\}^2 - [7.1701]\left\{5\text{h. }0\text{m. }40\text{s.} + A\right\}$$

$$C = -\tfrac{1}{2}\left\{A + B - \lambda'\right\}$$

In these equations

λ' = Assumed longitude from Greenwich, in seconds of time.
M = Local mean time of middle, observed.
M′ = do. computed by formula.
D = Duration, observed,
D′ = do. computed,
x = A correction for the errors of the tables.

The unknown quantity x, is the mean of the times at beginning and end, in which the moon by its apparent motion, traverses a space equal to the tabular error on its true orbit, projected upon its apparent orbit. No material error will arise from assuming x, as constant for the limits to which this formula extends. Of the extent to which it may be used, an opinion may be formed from the following table, in which the middle time M′ + B derived from it, is compared with the rigorous computations for several places in the American Almanac.

Place.	M′	B.	Middle by Formula M′ + B	Middle by Am. Almanac.	Difference.
Philadelphia,	8 17 55.35	+ 0.00	8 17 55.35	8 17 54.75	+ 0.60 s.
Boston,	8 42 30.80	+ 7.73	8 42 38.53	8 42 38.90	— 0.37
Providence,	8 39 42.55	+ 6.31	8 39 48.86	8 39 48.65	+ 0.21
Albany,	8 30 11.15	+ 0.60	8 30 11.75	8 30 11.80	— 0.05
New York,	8 25 1.45	+ 0.32	8 25 1.77	8 25 1.65	+ 0.12
Baltimore,	8 9 40.95	+ 1.69	8 9 42.64	8 9 43.20	— 0.56
Washington,	8 6 58.30	+ 2.56	8 7 0.86	8 7 0.30	+ 0.56
University of Va.	7 58 10.33	+ 7.37	7 58 17.70	7 58 18.15	— 0.45
					8)2.92
Greatest difference, 0.6 sec.				Mean difference, 0.36 s.	

The determination of x, requires observations under known meridians. This eclipse having been visible at European observatories, the value of x, will admit of accurate computation. If we assume the longitude of Independence Hall, Philadelphia, at 5h. 0m. 40s. west from Greenwich, we shall have, after correcting for the small differences of longitude of several places of observation in Philadelphia, the following values of x,

By the observations of	R. M. Patterson, M. D.	$x = -$ 11.15 sec.
"	T. M'Euen, M. D.	$x = -$ 9.67
"	W. H. C. Riggs,	$x = -$ 11.40
"	S. C. Walker,	$x = -$ 11.93
		44.15
Mean of four observations,		$x = -$ 11.04

As an application of the formula, let it be required to deduce the longitude of the Capitol at Washington, from the observations of F. R. Hassler, Esq. Latitude 38° 52′ 54.″ Beginning observed 6h. 53m. 58s. End at 9h. 20m. 8s., A. M. Mean time.

Computation of the longitude of the Capitol.	1st. Approximation.	2d Approximation.
(1) .... assumed λ'	— 5h. 8m. 7.20	— 5h. 8m. 10.02
(2) .... assumed λ	— 11.04	— 11.04
M	+ 8 7 3.00	+ 8 7 3.00
M′	+ 8 6 58.30	+ 8 6 54.88
(3) .... M—M′	+ 4.70	+ 8.12
D	+ 2 26 10.00	+ 2 26 10.00
D′	+ 2 26 13.60	+ 2 26 12.24
D—D′	— 3.60	— 2.24
(4) .... — [8.8557] {D—D′}	+ 0.26	+ 0.20
(1)+(2)+(3)+(4) .... A	— 5 8 13.28	— 5 8 12.74
5h. 0m. 40s.+A	— 7 33.28	— 7 32.74
(5) ... + [4.9781] {5h. 0m. 40s.+A}^{2}	+	+ 1.92
(6) ... — [7.1701] {5h. 0m. 40s.+A}	+	+ 0.67
(5)+(6) .... B	+ 2.56	+ 2.59
A+B	— 5 8 10.72	— 5 8 10.15
A+B—λ'	— 3.52	— 0.13
$-\frac{1}{5}$. {A+B—λ'} =C	+ 0.70	+ 0.03
A+B+C = λ	— 5 8 10.02	— 5 8 10.12

Similar computations from John Gummere's observations, give the longitude of Haverford School.

Observed	beginning	7h. 3m. 24.5s.
"	end	9 31 47.
"	latitude	40° 1′ 12″
	assumed λ''	5h. 1m. 26.8s.
First approximation	λ'	5 1 16.94
2d "	λ	5 1 16.15

Observations of the Solar Eclipse of May 15th, 1836. Communicated by direction of the American Philosophical Society.

TO THE COMMITTEE ON PUBLICATIONS.

GENTLEMEN:—By direction of the Amer. Philos. Society, I send you an abstract of the observations of the late solar eclipse, which have been communicated to the Society. It is not complete, some particulars being required which will probably be obtained from the observers, by the committee to whom the observations have been referred, to prepare them for publication in the Society's transactions.

The times of beginning and end are in mean time of the places of observation.

Very respectfully yours,

A. D. BACHE,

One of the Secretaries, Amer. Philos. Soc.

Table of observations of the beginning and end of the solar eclipse of May 15th, 1836, as observed at Philadelphia, &c.

Places of Observation.	Time of beginning of Eclipse.	Time of end of Eclipse.	Observers' Name.	REMARKS.
Philadelphia.	h. m. s.	h. m. s.		
1. Hall of Am. Phil.Soc	7 3 45.8	9 32 38.3	Dr. R.M. Patterson,	
2. Dr. McEuen's house,	7 3 38.0	9 32 38.1	Dr. T. McEuen,	2770 feet west of Philos. Hall.
3. "	7 3 50.0	9 32 26.5	Mr. W.H. C. Riggs,	
4. No. 100 S. 8th st.	7 3 40.9	9 32 44.1	Mr. S. C. Walker,	1340 feet west of
5. No. 231 Market st.	7 3 41.0	†9 32 34.0	Mr. Sellers,	Philos. Hall. Teles. 42 inches achrom.
Haverford school,*	7 3 24.5	9 31 47.0	Mr. Jno. Gummere,	Telescope 42 inch. achrom.
Germantown, Pa.	7 3 54.5	9 32 44.5	Mr. Isa. Lukens,	
	7 3 55.5	9 32 49.5	Mr. C. Wistar,	Telescope 3 feet achrom.
Phoenixville, Chest.co.‡	7 3 12.0		Mr. H. Wilson,	
West Hills, L. I.§	7 12 48.5	9 43 40.0	Mr. J. Ferguson,	Large repeating circle of coast survey, used for obser [vations.
Washington City,	6 53 58.0	9 20 08.0	Mr. F. R. Hassler,	

* Assumed lat. 40° 01′ 12″. Long. 5h. 01m. 25s. † Doubtful.
‡ Assumed lat. 40° 08′ 07.″ Lon. deduced by H. Wilson, from eclipse, 5h. 01m. 57s.
§ One of the station points of the coast survey. Lat. 40° 48′ 49.2″. Long. 73° 26′ 12″.

Essays on Meteorology. By JAMES P. ESPY, Mem. Am. Philos. Soc., &c.

No. III.

Examination of Hutton's, Redfield's and Olmsted's Theories.

In the preceding essays many facts independent of theory, have been adduced to prove an upward motion of the air in the region of a cloud, and many more will be adduced hereafter.

At present I propose to examine one of the many phenomena which I hink can be explained by this upward motion only; I mean the great quan-

tities of rain and hail which sometimes fall in a very short time. It was demonstrated in the first part of this essay, that the velocity of the upward vortex, in very favorable circumstances, is 4.5 miles a minute. In rising through that height it will precipitate a little more than one half its vapour, which will be about five inches of rain, so that in this case forty inches would be precipitated in eight minutes, provided it were all to fall in one place, which from the nature of the vortex, can seldom occur. That which is condensed above the point of perpetual congelation, should not be taken into the account; because at the moment of its condensation it becomes snow, and being so light will remain in the atmosphere long after the hail and the rain caused by the melting of the finer masses of hail, in passing down through the lower parts of the atmosphere, have reached the earth. Still there will be enough left to account for the most violent rains or hails, of which we have any account.

Here it may be worth while to turn aside for a moment, to examine the efficiency of the most plausible theory of rain that has ever been given to the world. I mean that of Dr. Hutton. He supposes two currents of air of different temperatures, both nearly saturated with vapour, to be mingled together, and that a precipitation of course takes place, in accordance with the known fact, that at their mean temperature all their vapour cannot be retained, and therefore the surplus will be precipitated. This theory is defective in two respects: First, it does not show how two currents of air could be mingled to any considerable extent; and second, it does not show by calculation, that rain to any considerable amount, would be produced, even if large masses of air at very different temperatures, should be mingled together, which it would be easy to show never can happen, especially in the torrid zone. It may fairly be presumed that no advocate of the Huttonian theory, would suppose that more than 500 feet of a stratum of cold air could be mingled with a stratum of warm air, 500 feet of perpendicular height. Now it will be found by calculation, that if one of these strata is at 60°, and the other at 40° and both saturated previous to their mixture, the whole amount of precipitation, provided they took the mean temperature of 50°, would be less than a grain and one half on each square inch of surface. But as the latent caloric evolved in the condensation of the vapour, would not suffer the mean temperature of the two strata, when mixed to be acquired, but some temperature above 50°, therefore a less quantity than that mentioned, would be precipitated. Such a quantity in most cases, would be entirely evaporated in passing down through the air below, and never reach the earth.

It was mentioned before that 5.1 inches of rain fell in Wilmington, on the 29th of July, 1834, in two and a half hours; let us see whether such a rain could be produced at all, on the Huttonian principles, making the most extravagant allowance for the quantity of air mingled, and also for the difference of temperature of the two strata.

Let us suppose then that one half of the atmosphere at 80° Fah., should be mingled with the other half at zero, over the region round Wilmington, and that 5.1 inches of rain is the result. What will be the temperature of the mingled mass after the rain? The mean temperature is 40°, which would be the temperature after the mixture, if no latent coloric is given out in the condensation of vapour. But from the principles explained before, it will be found, that as five inches of rain, is $\frac{5}{400}$ of the whole atmosphere in weight, the latent caloric given out in the condensation of the vapour forming this rain, will be sufficient to heat the whole compound 59.7°, which be-

ing added to the mean temperature 40°, will make the temperature of the air after the rain 99.7°, almost 20° hotter than the hottest half of the atmosphere before the mixture.

This result, however unexpected, ought not to appear surprising. For if gentlemen will frame theories on loose principles, without once putting these principles to the test of calculation, and without even taking the least notice of the latent heat of vapour, or the specific heat of air, they ought not to be surprised that a little plain arithmetic should dissipate their empty visions and "leave not a wreck behind."

Theorists will pardon me for this sweeping denunciation, when I now voluntarily come forward and plead guilty to the same charge; for I too have framed a hypothesis to account for rain, and advanced it under the high sounding name of theory.

Having found that the Huttonian theory would not bear the test of calculation, I imagined there was but one other possible mode of condensing vapour and that was that the vapour by its own elasticity in the lower parts of the atmosphere, thrust itself up into a cold stratum above, when ever such a one overlapped the one below, and was thus condensed into rain.

This hypothesis I thought was altogether reasonable from the great discovery of Dalton and Gay Lussac, that vapour in the atmosphere rests only on vapour, and thus forms an independent atmosphere, and is not supported in the least degree by the air. I imagined then, that vapour could rush with great velocity from air where the due point was high, to air where the dew point was low. But when I discovered that some rains were so great as to be beyond the power of this theory too, I began to suspect the hypothesis itself, which induced me to put it to the following trial.

I united two glass retorts together by their necks, then having covered one with snow, I put ten drops of water into the other and placed it in a vessel of water at the temperature of 130°, and let it remain in that situation seven hours, the temperature of the room during the experiment being about 70°; not one drop was distilled over in all that time.

I then took the retorts apart, leaving open the neck of the one having the water in it; it has continued in the room, open now for thirty days, with a temperature of 70° night and day, and the dew point in the room never as high as 40°, the ten drops of water being now only slightly diminished.

This refutes the hypothesis of rapid permeation of air by vapour, and indeed, proves that vapour, like heat, when it passes up to the upper regions, must be carried by the air, and not thrust up by its own elasticity. But to return from this digression; if the Huttonian theory is unable to produce such a rain as that at Wilmington, what will it do with the one which occurred at Geneva, on the 25th October, 1822, when it rained thirty inches in twenty-four hours; or the one at Jeyeuse, on the 9th October, 1827, when it rained thirty-one inches in twenty-two hours?*

Or how will it account for a storm of hail† which fell in Orkney on the 24th of July, 1818, in the afternoon, nine inches deep in less than nine minutes? And here it may be remarked that this is the storm mentioned before, in which the barometer was observed to fall two inches, near the end of the storm, when it was not nearly so violent as it was in other places. Or how will it account for the immense quantity of rain which fell at Catskill, New York, on the 26th July, 1819?

* Edinburgh Trans. 1823. † Pouillet Eliesmen de Phisique, II. 758.

About half past 5 P. M. a dense black cloud rose up from the S. W. accompanied with a fresh wind, and about the same time, or a little after, a very thick dark cloud rose up rapidly from the N. E. They met immediately over the town; at this instant a powerful rain commenced.

As soon as the clouds met they seemed to fall down on the river over which they met, and then the cloud rested on the water in such a manner that no space could be seen between them. For half an hour there was no appearance of drops of rain, the water appeared to descend in large streams and sheets. In this half hour the quantity fallen was above twelve inches on a level. Two persons testify that some time after the clouds met, they saw at the same moment a water spout rising up from the river nearly opposite, with a broad bottom ascending to the clouds with a whirling motion, in the form of a pretty regular cone.

The whole quantity which fell was more than fifteen inches, over a space of about eighty square miles; and as far as I can collect from the whole account which is given at large in Silliman's Journal, vol. 4, p. 124, this spout was stationary.

The intelligent author of the account, Benj. W. Dwight, says, it is worthy of remark that eleven days before in the P. M., there fell in a shower of short continuance, more than six inches of rain.

This theory has lately been brought forward and extended by Professor Olmsted of Yale College, with a view of accounting more particularly for hail, than the original author of the theory had done. And though I am aware that the strength of my theory does not depend on the weakness of any other, I think it proper to give the Professor's remarks a passing notice.

"We assign," says Mr. Olmsted, "as the cause of hail storms, the congelation of watery vapour of a body of warm and humid air, by its suddenly mixing with an exceedingly cold wind, in the higher regions of the atmosphere. Let us examine, says he, the effects which would result from the meeting of two opposite winds, at the height of 10,000 feet, during the heat of summer, the one blowing from the latitude of 30°, or from the confines of the torrid zone, and the other from the latitude of 50°, or the northern part of British America. If they had equal velocities, they would meet at the parallel of 40°; and, as in the case of the Gulf stream, a fluid does not readily change its temperature, merely by flowing through a body of the same fluid of a different temperature, and especially air through air, each current would retain nearly its original temperature.

The southerly wind blowing from a point which is still 2,000 feet below the line of perpetual congelation, is comparatively warm, while the northern coming from a point 4,000 feet above the same boundary of the empire of frost, will have a degree of cold, probably surpassing any with which we are acquainted. We infer from our preliminary principles, that immediately on meeting, the watery vapour of the warmer would be frozen with an intensity corresponding to the temperature of the colder current; that the minute hail stones thus formed and endued with such excessive cold, would begin to descend, and accumulate to a size proportionate to the intensity of the cold of the nucleus, and to the space through which they descended, and to the humidity of the lower strata of the atmosphere; that is, the colder they were when they began to fall, the farther they fell, and the more humid the air, the larger they would become."

As Professor Olmsted has not shown how these currents could be generated, the theory is plainly incomplete on this ground. And besides, even if they

should be generated, it does not appear how they could be mixed; for either they would meet each other in opposite directions, and so stop each other's motion without mixing to any great extent, or they would slip by one another without much affecting each other's temperature, according to the Professor's own reasoning.

But even if it could be shown that a mixture of two currents could take place suddenly, of even 1,000 feet in perpendicular extent, it has been proved already that under much more favorable circumstances, the dew point being higher, a grain and a half of rain to the square inch would not be precipitated, and that in most cases not a particle of this would reach the ground, for it would be evaporated in its descent, unless the air below should happen to be absolutely saturated with vapour, which seldom occurs.

But, according to Mr. Olmsted, "the minute hail stones being indued with a cold probably surpassing any with which we are acquainted, would begin to descend and accumulate to a size proportioned to the intensity of the cold of the original nucleus."

This remark is erroneous in two respects. First, the cold is certainly not more intense at this great elevation, than one degree for every 100 yards, and is therefore in the northern current only $13\frac{1}{3}°$ below the freezing point; for by supposition it was only 1333 yards above the line of perpetual congelation, when it left latitude 50°.

Second, the original nucleus would not accumulate in the manner described; but on the contrary it would be entirely melted by the time it had descended far enough into the air below the line of perpetual congelation, to have condensed vapour less than one-seventh of its weight. This will easily be perceived by comparing the relative latent heats of vapour and of water, and this too even if it received no heat from the warm air into which it fell. But even if the original nucleus were of the temperature of the interplanetary spaces, 57° or 58° below zero, it would not increase one-fifth in size by condensing on itself the vapour, before it would be entirely melted by the disengaged latent caloric.

Professor Olmsted concludes his essay by saying that the momentum of a hail stone would be one hundred times greater if it did not at every stage of its progress down to the very ground, receive new accessions of watery vapour, which being matter at rest, is to be put in motion by the falling body, and consequently its speed is continually retarded.* But he must now perceive, from what has already been said, that the velocity of descent will not be diminished one-fifth, even when the stone has received an addition of vapour great enough to melt it.

Before I take leave of this extension of Hutton's theory, I must take notice of another remark made by Professor Olmsted, which if correct, would of itself prove fatal to the theory which I have advanced. He says, "we have certain evidence from the concourse of opposite winds, and from the density and consequent blackness of the clouds, that a great condensation takes place in the region of the storm."

Now it appears to me that it would be much easier to account for the concourse of winds, by supposing a rarefaction in the region of the storm, just as the rarefaction in a chimney is the cause of the air in the room moving towards the fire place. It shall be shown hereafter what effect would be produced by a condensation in the region of a storm.

I come now to a most important part of this investigation, the northeast

* Vide Silliman's Journal, vol. 18, p. 1.

storms of the Atlantic states. It is well known since the days of Franklin, that these storms commence in the south west and travel towards the north east with a velocity which varies at different times and places, and that the wind always blows from some eastern point at the commencement of the storm.

Mr. Redfield of New York has collected a great many highly interesting facts connected with these storms, of which some of the most important shall now be detailed.

When a storm commences within the torrid zone it travels west of north until it reaches lat. 30°, when it has become nearly north, it then gradually deflects more and more east of north, until about lat. 40°, it is moving about N. E. That these storms are probably nearly round, varying in diameter, and more slow in their advance along the coast, in proportion to their size, and also slower in low latitudes than in high. That on their north western side, the wind sets in more northerly and changes round during the storm by north, and on the south east side of the storm the wind sets in at the commencement more easterly and south easterly, and changes round by the south.

Mr. Redfield thinks that these facts can only be accounted for on the supposition, that these storms are exhibited in the form of great whirlwinds.

As a more particular proof of this position, he details the facts which occurred in Connecticut, as one of these storms passed there in 1821. He says, "that the mass of atmosphere upon the earth's surface was moving for several hours, apparently towards the N. W. over Middletown, with a probable velocity of seventy-five or one hundred miles per hour, while in the northern parts of Litchfield county, at a distance say of forty miles, the wind, at about the same period, was blowing with nearly equal violence in the opposite direction towards Middletown." Now it will appear by a little reflection, that all these facts agree with the idea of an upward vortex, more consistently than with a horizontal whirlwind.

Indeed I do not hesitate to say, that the last fact is inconsistent with a horizontal whirlwind, and proves with irresistible evidence, the existence of an upward vortex, at least in this storm. For two winds cannot blow towards each other for several hours as here described, without either rising upwards when they meet, or blowing outwards at the sides. But we have proof positive, that they did not blow outwards at the sides, for at N. York, S. W. of the point between Middletown and Litchfield, to which the winds from those places were blowing, the wind changed round by the N. to the N. W., or W. about the time these winds began to blow violently. And we have strong reason to believe that it did not blow outwards to the N. E.; for at the commencement of the storm, through its whole course, the wind always blew from some eastern point.

There is one conclusion which Mr. Redfield draws, which I do not find to be justified by the facts detailed in this storm. "That along the central portion of the track, the storm was violent from the south eastern quarter, *changing suddenly to an opposite direction.*" Now I find, that of fifteen points on the south east side of the storm, at which the wind set in S. of E. only two, Bridgeport, Conn. and one at sea, forty miles north of Cape Henry, are given, as having the wind to change round, even as far as the west. These two, I *suspected* as being contrary to my theory; and upon examination of the newspapers of the day, I find that they report the wind at both these places to have changed round only to the S. W., just as far as it *should* change to satisfy my theory.

All these facts lead to the conclusion, that in this storm, at least the wind in the neighborhood of the storm, blew directly towards its centre, and if so, it follows beyond all doubt, that there was an upward vortex in the middle of the storm. Now as it is impossible to conceive of an upward vortex being formed in the region of the storm, if there is a condensation of air there; so it can only continue on the supposition that the air, as fast as it arrives in the vortex from all sides, becomes rarefied, whatever may be the cause of that rarefaction.

As it has been said that a condensation in the region of the storm would cause an afflux of air there, let us for a moment examine the assertion. Suppose that no latent caloric is given out in the condensation of vapour, and that in a circular space of one hundred miles in diameter, five inches of rain have fallen, the whole condensation which would take place by the change of vapour to water, would be less than a fiftieth of the whole atmosphere, and the air on all sides of the storm, would not have to move one mile towards the centre, before the equlibrium would be restored. Besides it is manifest that this motion could not take place at the surface of the earth, but rather in the region of the cloud and above it. And even if the velocity at the surface of the earth is supposed to be as great as in the region of the cloud, it could not be a mile an hour, for it never has been known to rain five inches an hour in a storm of this magnitude, and the condensation of the air is supposed to take place during the whole rain.

I have myself had the pleasure of seeing and pointing out to many of my friends at various times, particularly to Professor Bache, the clouds moving outwards above, and inwards below, during a summer's thunder gust, which could not be, if there was a condensation of air in the region of the cloud, and I may add without the fear of contradiction, that it proves the reverse. Besides, I have known many instances of long continued and violent rains in the south, during the prevalence of a strong and long continued north wind, and of long continued and violent rains in the north, during the strong and long continued south wind.

An instance of the latter occurred on the 11th, 12th, 13th, 14th, and 15th of May, 1833. In my journal it is stated that a strong south wind prevailed during this whole period night and day. And by consulting the papers of the period, I find the following facts:

Harrisburg, May 16, 1833. When our paper went to press the Susquehanna was sixteen feet above low water mark, and rising—a greater freshet than has taken place for sixteen years—the rain must have been much greater up the river than in the vicinity.

Albany, 15th. The most painful accounts begin to be received of the destructive effects of the freshet. The river continued to rise until 10 o'clock this morning, when it was a foot higher than it was in the great freshet occasioned by the ice in the spring. On the 17th, it had fallen only a few inches.

The *Amsterdam* (Mohawk Herald) of the 16th, says, "every bridge and mill dam on the creek near Fort Johnson has been swept away."

Hartford, 18th. The water in the Connecticut last evening, was 19½ feet above low water mark.

Montreal, May 15th. A larger quantity of rain has fallen here since midnight of last Friday, (five days) than we have had for a considerable period past, and the rain is now falling in torrents, the atmosphere cool and very unpleasant.

The *Goshen* Patriot, says the Delaware rose twelve feet above an ordinary freshet—not a raft above Milford was preserved entire.

These facts afford conclusive evidence that in this case at least, the wind at Philadelphia blew hard for five days, exactly towards one of the greatest rains which our country has ever witnessed. And the statement, that the atmosphere at *Montreal* was cool and very unpleasant, would lead us to suppose that the wind there was coming from some northern quarter; for during this whole period the temperature was very high in Philadelphia, the mean minimum being 65°, and the mean maximum 76°, and if a southern wind prevailed there, it is not at all likely that the air would have been cool and unpleasant.

Again, from the 3d of June, 1835, to the 12th of the same month, the wind was constantly from the north, with one exception from north east, pretty strong for a considerable portion of time.

I find by the *Charleston* Courier, that a dreadful storm of rain set in there on the 3d, and another very violent one on the 8th, which was increasing when the paper went to press on the 9th at 10 P. M., and that on that day there had been no mail from Fayetteville, and that there were six letter mails due from N. Y. and Boston, and five from Washington, Baltimore, and Philadelphia.

All these facts seem utterly at variance with a horizontal whirlwind; and entirely consistent with an upward vortex, if they do not absolutely prove one.

If Mr. Redfield should perceive that all the interesting facts which he has with such laudable industry collected, are fully explained by a theory which accounts also for the rain, I am sure he will not be very tenacious of his horizontal whirlwind; especially when he does not pretend to show that either the whirlwind is the cause of the rain, or the rain the cause of the whirlwind. Let us, however, examine for a moment (for I should be proud to enlist Mr. Redfield under the banners of a true theory) what would be the phenomena, on the supposition that there is a horizontal whirlwind, say of one hundred miles in diameter, moving with a velocity of seventy-five miles an hour, or 110 feet per second. It is demonstrated in mechanics that if a body moves in a circle, with a radius of sixteen feet, and a velocity of sixteen feet per second, its centrifugal force will be equal to its gravity. And as centrifugal force is directly as the square of the velocity, and inversely as the radius, the centrifugal force of the air in this whirlwind is ascertained by the following proportion:

$$\frac{16^2}{16} : 1 \text{ (gravity)} :: \frac{110^2}{25\times5280} : \frac{1}{74} \text{ or } \tfrac{1}{74}\text{th part of the gravity.}$$

And as a wedge of air fifty miles long is about eight times as heavy as a column of atmosphere equal to its base, its whole centrifugal force will be $8\times\frac{1}{74}$ of fifteen pounds to the square inch, which would cause the barometer to rise about $1\frac{4}{10}$ of an inch in the borders of the storm, both at its commencement and termination; and cause a motion of the air outwards due to this pressure, which would be about 280 feet per second, according to the principles established in a previous part of this essay. Now these two phenomena are entirely wanting in all N. E. storms; for the air does not blow outwards from the storm, nor does the barometer rise at the termination above the mean, though it sometimes does at the commencement, for a reason which shall hereafter be explained. Besides, if such a whirlwind could be generated, it is manifest that it would soon be destroyed by its

outward motion, unless some mighty cause exists, of which we have no knowledge, to generate new motion in the air, which would descend from the upper regions of the atmosphere in the middle of the whirlwind, to take the place of that which had thrust itself out by its centrifugal force. It may be added, that the readiness and ease with which the air would descend in this whirlwind, would be so great that the rarefaction of the air in the inside, caused by the centrifugal force of the air would be a quantity very minute, unless we suppose the whirlwind to reach to a great height, which cannot be the case, if it is produced by friction on the West India Islands, and on our coast, as is alleged.

Therefore, it will not account for the great fall which is known to take place in the barometer, during these violent storms, a fact which is fully explained by the theory here proposed. Besides, Mr. Redfield need not be told that this downward motion of the air in the centre of the whirlwind, would increase its capacity for vapour, and effectually prevent deposition.

Bibliographical Notices.

Concise decimal tables for facilitating Arithmetical calculations, &c., designed for practical men. By Timothy Claxton, Boston. *Published by the author.**

A sheet containing one of the most concise series of tables which we have ever seen, for facilitating arithmetical operations, has been published by the author, Mr. T. Claxton of Boston. It is accompanied by a pamphlet explanatory of the tables, and containing also an exposition of the system of decimal fractions, a list of data from which the tables are compiled, and an index to them.

The tables may be classed as mathematical, mechanical and miscellaneous. The former contain tables for finding the circumferences and areas of circles from their diameters, the diameters from the circumferences, and square roots of the areas, the side of a square equal in area to a circle from the diameter or circumference given, &c., the solidity of a cone from the square of the diameter of its base, and its height, and a sphere from its diameter, &c. &c. Among the mechanical tables are a series for the reduction of weights and measures, for calculating the weights of solid and hollow cylinders of cast-iron, the weight of square and round bars of iron, of spheres of cast-iron, lead, &c. all from convenient data. Among the miscellaneous tables, are those for reducing sterling money to dollars, or vice-versa, the amount of rent or salary for any number of days, having the annual amount &c. &c. There are in all, forty-eight tables conveniently arranged upon a sheet of 10 by 13 inches which may be hung up in the counting-house, or folded for the pocket, for reference.

These tables recommend themselves highly for convenience, and as far as we have examined the calculations we have found them correct. B.

* The Franklin Institute owe to the liberality of the author a number of copies of these tables, which he has requested may be distributed among the members. His object in the publication, is the dissemination of what he justly conceives to be useful matter. Com. Pub.

The Steam Engine familiarly explained, with a historical sketch, &c., by the Rev. DIONYSIUS LARDNER, *with additions and notes by* JAMES RENWICK, L. L. D., *Prof. of Nat. Exper. Philos. and Chem. Columbia College, N. Y.* Second American from the fifth London edition. Philadelphia, Carey and Hart, 1836.

This is a new editon of *Lardner on the steam engine*, presented in an enlarged form, and with considerable improvement in both the matter, and the manner of getting up the work.

The principal additions consist of a view of steam navigation, a description of important points connected with the economy of steam power, and compendious maxims for the guidance of those engaged in rail-way enterprises. Besides these, there are minor additions and improvements. We have often heard it urged by practical men, that they have been disappointed in the information given by Lardner, in the former editions of this work. This was plainly because they expected to get from the book information which it was not intended to give. It is not intended to furnish a practical discussion of the steam engine, either stationary, as applied to navigation, or to locomotion on common roads and rail-ways; of course the reader who consults it for such a purpose, must experience disappointment. But the general reader, or the student who wishes to obtain a correct idea of the principles of the steam engine in its various applications, will be gratified by the lucid descriptions, the happy arrangement and manner of the author, the easy style with which the subject flows; and will find when this work has been carefully read, if he wishes to go deeper into the subject, that he can consult more profound treatises, with many fold the advantage which he would have derived, without this previous preparation. This is of course not the place for a particular review of the minutiæ of the work, but in conclusion, we may add, that we consider it as materially increased in value, by the general accuracy of the American edition, which is guaranteed by the name of Professor Renwick. B.

Franklin Institute.

Monthly Conversation Meeting.

The Ninth Monthly Conversation Meeting of the season was held at the Hall of the Institute, on the 26th of May.

Mr. Chas. F. Voorhies, of Philadelphia, exhibited a portable printing press of very compact form, designed for card printing and other light work.

Mr. Allen Ward, explained the principles upon which he constructs his scales of equal parts, for the use of tailors, and exhibited several diagrams illustrative of the method of adapting the scale to the peculiarities of shape. and the variation of fashion. Mr. W. has been very successful in reducing to mathematical precision, this intricate art.

COMMITTEE ON SCIENCE AND THE ARTS.

Report on Mr. Amasa Holcomb's Reflecting Telescope.

The Committee on Science and the Arts, constituted by the Franklin Institute of the

State of Pennsylvania for the promotion of the Mechanic Arts, to whom was referred for examination, a Reflecting Telescope, invented by Mr. Amasa Holcomb, Southwick, Massachusetts, REPORT:—

That the following description of the instrument, submitted to the Committee, is given by Mr. Holcomb, viz:

"It is of the reflecting kind, having the front view, and has a focal length of about nine and a half feet, and an aperture of eight and a half inches. It has six eye pieces, of powers from ninety to nine hundred and sixty."

The evenings of the 22d and 23d of April, proving unfavorable, a third trial was made on a following night, when the performance of the instrument was very satisfactory. It is of the same size as the largest submitted last year. The mechanical execution of the mounting is quite superior, and leaves little to be desired, whether we regard steadiness, convenience in command of the instrument, or facility of finding objects.

The committee do not hesitate to pronounce this instrument superior in performance to any that have yet been exhibited by Mr. Holcomb.

The ring of Saturn was seen to be double by all the members of the committee present, the dark space between the rings could be observed on each ansa, half way to the conjugate axis of the perspective ellipse, under which it was viewed.

ζ Bootis which last year was so far separated that the discs became tangent to each other, presented the same appearance this year, with a power of 250. But with a power of 960 the dark space between the stars was equal to one-fourth of the disc of either.

In ζ Cancri, the close pair, distant about 1″.1, were so far separated that the dark space was visible as a line between them. This was considered too difficult for either of the telescopes exhibited last year.

A power of 960 was used in examining γ Virginis. This remarkable pair, of which the distance is 0″.8, according to Herschel's ephemeris, or 0″.6, according to Struve's late measurements, gave no indications of being double.

This instrument was made to order for John A. Fulton, Esq. of Chilicothe, Ohio, a gentleman whose liberal encouragement of this department of the arts is worthy of all commendation. While, however, the committee would applaud the patriotism of those individuals, or corporate bodies, who encourage American artists, they cannot but remark, that should the course of Mr. Holcomb be suddenly arrested, and the manufacture of these instruments cease in this country, their place could hardly be supplied by importation, at three times their present cost.

The four or five choice instruments made by Mr. Holcomb, have been the result of twice as many years of labour and perseverence, for which no adequate compensation can have been expected, except that satisfaction which every lover of science feels, in improving and extending the means by which it may be pursued.

The committee have little doubt that under proper auspices, and at an expense not exceeding that already encountered by some of our corporate institutions, in procuring instruments of little use, a twenty foot telescope might be made, which should do honour at once to the artist and the country.

By order of the committee.

March 11, 1836. WILLIAM HAMILTON, *Actuary.*

Mr. C. Wesener's manufacture of Artificial Soda.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania for the promotion of the Mechanic Arts, to whom was referred for examination, Mr. C. Wesener's manufacture of Artificial Soda, REPORT:—

That they have examined the various samples of artificial soda laid before them, and after a careful comparison of them with different specimens of Barilla, from Teneriffe and Sicily, are of opinion that these products may advantageously supply the place of the imported salts, for most purposes in the arts, as from a comparative trial made by means of the alkalimeter of Duscroizilles, it was satisfactorily shown that the proportion of soda in the several qualities manufactured by Mr. Wesener, rather exceeded that contained in natural barilla of about the same market price. There is, it should be stated, no novelty in the manufacture of this article, except that it is procured from the sulphate of soda, left as a residue in the making of nitric acid, from the native nitrate of soda from Peru, instead of from the same sulphate left after the extrication of muriatic acid from common salt; the artificial soda made from the last mentioned residue, almost always contains some chlorine, from which it is difficult to free it, whilst that made by the process of Mr. Wesener, is wholly free from this body.

The great consumption of the inferior qualities of soda, is by the soap makers, who are in the habit of using the natural barillas in preference to the artificial, from an idea that they are better and give out less sulphuretted hydrogen; the presence of this offensive gas, although of no consequence as regards the quality of the soap, is a serious evil where the manufacture of soap is carried on in a city, as is the case with most of our establishments of this kind. Mr. Wesener, has however, obviated this, by the preparation of an article which can be afforded at about the same price as natural barilla, and containing 62° of soda, which is entirely free from hydro sulphuric acid, and which hence can be employed by the soap boiler, without creating the nuisance usually attended on the lixiviation of the salts used by him.

By order of the committee.

May 12, 1836. WILLIAM HAMILTON, *Actuary.*

Report on Mr. Charles Potts's Pumps for Steam Engines.

The Committee on Science and the Arts, constituted by the Franklin Institute the State of Pennsylvania for the promotion of the Mechanic Arts, to whom was referred for examination, a Pump for Steam Engines, invented by Mr. Charles Potts, of Philadelphia, REPORT:—

That the inventor proposes (for the purpose of supplying the water to steam boilers) to employ, in lieu of the ordinary forcing pump, a contrivance by which the water runs into the boiler by its own gravity. It consists of a chamber, or cavity, connected with the boiler below, and a tank or reservoir above it, and communicating with them alternately, first filling with water from the tank and then emptying it into the boiler, into which it passes by its own gravity in exchange for an equal bulk of steam.

In regard to the important question of novelty, the committee have to state that the proposed plan is familiar to them, but it is considered to be of doubtful utility, as the chamber must be below the temperature of boiling water at the time of filling, and again raised, at least in part, to that of the

steam in the boiler, before it can be made to descend into the boiler. They consider, however, that the apparatus is worthy of a renewed trial.

By order of the committee,

May 12, 1836. WILLIAM HAMILTON, *Actuary.*

Mechanics' Register.

AMERICAN PATENTS.

LIST OF AMERICAN PATENTS WHICH ISSUED IN JANUARY, 1836.

With Remarks and Exemplifications by the Editor.

1. For *Water proof Silk Plush Hats;* George Blake Dexter, Boston, Massachusetts, January 6.

This patent is taken for what is deemed an improvement in the manipulation of applying the silk plush to the body of the hat, after it has received the ordinary coating of dissolved caoutchouc, by which it is made to adhere; the process consists mainly, in passing a metallic cylinder over the plush so as to press it against the body of the hat, and cause it to adhere to it. This cylinder is, we apprehend, formed by bending a metallic plate so that its ends shall nearly meet, and around this a band of India rubber is to be placed, which by its elasticity, is to keep the metal in close contact with the crown. The description is not very clear, but such is our understanding of the thing. The claim is to "the improvement in the application of plush or any other fabric to the body of the hat, by means of a bent metal plate, and by an operation as above described."

2. For an *Elastic revolving belt Saw;* Benjamin Barker, Ellsworth, Hancock county, Maine, January 6.

The patentee says, "what I claim as my invention, and not previously known in the above described machine is, the elastic revolving belt saw, and the manner of using the same. I do not therefore, claim as my invention any of the other several parts of said machine, nor their particular combination." If the patentee could have made any new arrangement of the parts for operating this saw, he might have claimed such arrangement with some propriety, but the saw itself which he does claim is quite an old affair; it is mentioned in Rees' Cyclopædia; has previously been patented more than once in the United States; has been repeatedly tried, and as frequently abandoned as worthless in operation; and such will again be its fate, should it again be essayed by the present patentee.

3. For a *Forest, or Tree Saw;* Walter Hunt, city of New York, January 6.

Considerable ingenuity has been displayed in the arrangement of the apparatus described and figured by the patentee, who has made his invention fully known. The apparatus consists of a *grapple* by which the whole is to be attached to the tree to be felled, by means of a screw, spike, &c.; the *lever,* to which one end of the saw is to be attached, and which, by being moved backward and forward horizontally, operates on the saw; the *saw* and a *spiral spring* by which the latter is to be kept up to its cutting bearing.

The particular construction of these parts we shall not attempt to describe. The patentee claims "the style of construction, combination, and arrangement of the *forest tree saw*, as above specified, &c." We shall not, as we have said, attempt a particular description of the proposed arrangement of the parts of this machine, but predict that it will share the fate of other saw machines for felling trees, and be found by far less efficient than the axe of the woodman. We apprehend that the patentee has not had much experience in clearing land, or he would have known that his wedges and other contrivances would not enable him to determine the direction in which his tree should fall, and that the experienced axeman is sometimes at a fault in this particular, an event which would be fatal to the whole apparatus before us.

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4. For *Separating foreign seeds from Clover Seed;* James Manning, Lambertsville, Hunterdon county, New Jersey, January 6.

A screen, or riddle, is to be made in the form of a flour bolt, or otherwise, and this is to be covered with wove wire, the meshes of which are oblong, and a little narrower than the diameter of the clover seed; the claim is to the "making these apertures of an oblong figure." This patent will take rank with those which are the least worthy of an exclusive right, for however good such a screen, sieve, or riddle, may be, it has been so common as to render the idea of claiming it as a novelty truly ridiculous.

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5. For a *Washing Machine;* Joab H. Hubbard, Bloomfield, Harford county, Connecticut, January 6.

By this machine the clothes are to be "pounded" in a box, upon the bottom of which there are pins projecting upwards; the pounders, two in number, having pins on their lower sides which pass into the spaces between those within the box. The pounders have each a rod extending up from them through the lid of the box, and these being operated upon by cams and springs, are raised by the former and forced down by the latter. A horizontal shaft carrying a cog wheel, and turned by a winch, causes a second shaft, having a pinion on it, to revolve, this latter, carrying the cams, or lifters—rather a complicated child of ingenuity this, and one, which we opine, will not find many foster mothers.

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6. For a *Machine for cutting Wooden Screws;* Joseph Peavy, Levant, Penobscot county, Maine, January 6.

This machine for cutting male and female screws upon wood, differs so little from others which have been used for that purpose in large manufactories, as not to require any particular description. The V is fixed upon a sliding frame, the piece to be cut being contained in another frame, in which it is made to revolve by turning the guide screw, which at the same time forces the V frame forward. A similar apparatus, with a suitable cutter, is used for the female screw.

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7. For *Dyeing and colouring Hats;* Aaron Gould, Washington, Litchfield county, Connecticut, January 6.

The hats are to be put into a basket, or crib, and this placed in the dye kettle, and taken out for airing in any way that may be preferred, until the colour becomes perfect. This is all, but is it new?

8. For an improvement in *Locks for Doors;* Solomon Andrews, city of Perth Amboy, New Jersey, January 11.

In this lock, which is intended chiefly for large doors, the cam part of the key consists of several pieces which are passed on to the shank, and being of different lengths, may be variously combined, thus admitting of numerous changes by corresponding changes in the tumblers upon which the cams of the key are to operate.

There are eight distinct claims made to the different parts of this lock, which, however, would not be understood, if given without the drawings and description. In the general mode of combination and action by means of movable cams and tumblers, it bears considerable resemblance to the lock patented by Mr. Kyle, described in vol. 10, p. 331.

9. For a *Mill for cutting Grain and other articles;* William Gerrish, Portsmouth, New Hampshire, January 11.

Two iron plates from six to eighteen inches in diameter, constitute the cutting, or grinding, part of this mill. The under plate is to be the runner and to be driven by any proper gearing; both plates are to be slightly conical. The upper plate is to have several perforations in it, which are to receive cutting irons, fixed and operating in the manner of plane irons. Besides these cutters there are ridges, or teeth upon the grinding faces. The claim is to "the cutters and cavities, their particular arrangements and principle, applied to this purpose."

10. For *Building Wharves, Piers, &c.;* John G. Pray, Brooklin, King's county, N. York, January 11.

The building of wharves, piers, and breakwaters, is treated in this specification, as a very simple and easy affair, but it certainly is not rendered so by the clearness of the description, or by any references to the drawing; the former being extremely general in its terms, and the latter, although well enough executed, showing a wharf in its finished state, and without any references whatever; nor is there any claim made to any part of the invention.

After the foundation has been laid, "which is done with the greatest ease, blocks, piers, or pillars of any dimensions, may be raised thereon in the following manner," &c. &c. We are to take blocks of stone, or of cast-iron, eight or ten feet long, and one or two feet square, and provide two of them with a *conductor* at each end, one or two inches in diameter, so placed that when the stone is laid for the foundations, the conductors will rise above the water, down these the stones, or blocks of iron are to be slid, they being, we suppose, drilled with holes through them for that purpose. The stones, &c. are to be piled up in this way, the second laying transversely upon the first. The ends having been prepared so that they will come together in a dovetail. When raised to a sufficient height they are to be arched over. We think any thing further unnecessary, the foregoing being a fair example of the mode of description adopted in this specification.

11. For *Dressing and Napping Cloth;* Stephen Marsh, Jerico, Chittenden county, Vermont January 11.

This machine in its general construction, resembles those now in common use for the napping of cloth, but the patentee thinks that considerable advantage is derived from causing the card teeth on the napping cylinder to

stand in the direction of radii, or nearly so, from its centre. "Said Stephen Marsh, claims as his invention, the direction of the card teeth, radiating in direct lines from the centre, or axis of the cylinder, or having a less inclination than those which are now, or heretofore have been, in use. Also the passing the pivot of one wheel through the axis of rotation of the other, and the general arrangement and combination of the machinery as set forth." We doubt the validity of the claim to the radiating, or nearly radiating, teeth, as we believe that they have been frequently so employed. The other point claimed is a mere matter of arrangement, not at all necessary to the action of the machine.

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12. For a *Machine for Drilling Wood, Metal and Stone;* William Roy Jones, Granville, Washington county, New York, January 11.

If this be an improvement in the mode of drilling and boring, we should prefer some unimproved machinery that we have seen in use. A frame is made, having a bed upon which to place the frame to be drilled or bored; the drill is fixed in the lower end of a vertical shaft, or mandrel, which is to be turned by a winch on its upper end. The mandrel passes through the centre of a wooden, or metallic, screw, turning in a nut in the upper part of the frame, which screw is to be forced down by a handle on its upper end, just below the above named winch. The claims "are to the crank (winch) on the end of the screw passing through the nut, and the screw pressing on the shoulder of the mandrel."

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13. For *Hanging Carriages by means of tubes and spiral springs;* Henry Mellish, Walpole, Cheshire county, New Hampshire, January 11.

"The invention here claimed is the combined application of the springs and tubes to the above named purpose." The contrivance consists simply of a spiral spring of wire enclosed in a tube, with such appendages as are necessary to attach it to the carriage, and to cause the weight of the body to rest upon the springs. There is no novelty whatever in the employment of spiral springs, contained within tubes, for hanging carriage bodies, but they have been found so much less to be depended upon than springs of the more ordinary kind, that they have uniformly, after trial, been thrown aside.

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14. For a *Machine for Planting Corn;* Charles R. Belt, Washington county, District of Columbia, January 15.

There are many patented machines for planting corn, cotton, and other seeds, so nearly resembling each other, as to constitute different modifications only of the same machine, and such is the character of the one before us. The claims made are confined to two particular points in which the patentee considers his machine as excelling its predecessors, but its superiority not being apparent to us, we shall pass on to other matters.

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15. For a *Plough;* John Dolhaner, Canton, Stark county, Ohio, January 15.

There is nothing claimed as new in this plough, but the mode in which the parts are fastened together, so as to give it the desired stability.

16. For an improvement in the *Construction of Bedsteads;* Jonas Maguire, city of Philadelphia, January 15.

Dowells are to be put into the ends of the rails instead of cutting tenons thereon, and corresponding holes are to be bored into the posts to receive the ends of these pins, or dowels; screws are to be used for fastenings, in the usual way.

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17. For *securing Wells from the influx of Surface Water;* Levi Kidder, city of New York, January 15.

"The principle of this improvement consists in the construction of hydraulic cement, of a protecting cover and sides to wells, cisterns, reservoirs, and other vessels in the earth, whereby the water within them will be secured against the influx of surface water, and the intrusion of vermin in the mode and by the means substantially as described."

The mode described is to raise a wall of cement upon the ordinary wall of the well, to cover this with a top in the form of a dome, leaving an opening in the middle for the pump body.

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18. For the application of hydraulic cement to making *Covers for Wells, &c.;* Livi Kidder, city of New York, January 15.

This patent is taken for covers pretty much like those above described; that is to say, a cover for wells, cisterns, &c. is to be made in the form of a dome, leaving a suitable opening for a man to pass through, or for other purposes; it appears, however, that the design is to secure the particular mode of forming such covers, which is as follows:

A mound of earth is made in the shape of the inside of the cover, and upon this mound the cement is to be cast, or spread, to the thickness of four inches, more or less. When the cover is large, it is to be divided into sections of a convenient size for removal. "The improvement which this applicant claims to have invented, consists in making said covers, not upon the well, cistern, or other vessel, where they are to be used, but in a shop or suitable manufactory in which they can have time to season, and from which they can afterwards be removed to the place of use."

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19. For a *Machine for pressing Tobacco in;* J. Beverly Allen, city of Richmond, Virginia, January 15.

This machine for pressing tobacco in, is merely a square box, four of the sides of which are of tin, the other two being of wood. The patentee says that "before this box was invented the manufacturers of pressed tobacco were compelled to use oaken boxes, the material for constructing which has recently become very costly, and difficult to be obtained. What I claim as my invention, and not previously known, in the above described machine, is the use of tin for four sides thereof, instead of wood, which was before exclusively used."

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20. For an improvement in the *Machinery for forming and hardening Ropes, of any required length;* John Whiteman, city of Philadelphia, January 15. (See Specification.)

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21. For an improvement in *Trunks, Valises, &c.;* James W. Noble, Pittsfield, Berkshire county, Massachusetts, January 15.

There is not any thing furnished by the patentee which amounts to a de-

scription of his mode of making trunks, valises, &c.; we gather, however, from what is said, that there is to be a frame, to which the leather used, is to be attached by means of rivets, without the use of sewing, or of tacks. The frame, we suppose, must be of iron, perforated so as to receive the rivets; but even this is matter of conjecture; yet, if the story told be correct, the improvement is worthy of a good specification, as we are informed that this trunk, &c. will possess great strength, and compactness, require less leather than ordinary in the construction, and produce a saving of seven-eighths of the time ordinarily consumed in the manufacturing of such articles.

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22. For a *Plough;* Samuel Witheron, Gettysburg, Adams county, Pennsylvania, January 15.

The whole description is as follows: "The improvement consists in placing a roller under the beam, near the centre of the plough, in or near a perpendicular position; the roller may be made plain, ridged, grooved, or otherwise. The use of the roller is to prevent the plough from choaking, by rolling off the vegetable matter that usually collects under the beam."

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23. For an *Art, or method, or process, of lessening the consumption, and of increasing and otherwise improving the effects of fuel;* Isaac Orr, Washington, District of Columbia, January 20.

It is not easy from the title, to tell for what this patent has been obtained; whether for a stove of a particular construction, or for the art of managing the fuel. The claims, however, fifteen in number, relate principally to matters of construction, but in a way so general and diffusive, as not by any means to enable us to distinguish those things which are intended to be the subject of the patent "from all other things before known or used," as required by the act of Congress. The principal feature in the stove which the patentee denominates the *air-tight stove*, is the so constructing, or making, the sliding or other doors which open into the stove, that when closed they shall be, as nearly as may be, air-tight, by which means the combustion of the contained fuel, may be completely controlled, and but little, or no, consumption take place, whatever may be the quantity within the stove. That such a stove cannot, and must not, be made perfectly air-tight, will be at once admitted, and we are not aware at what degree of good fitting, the affair would be entitled to a patent. We have a stove in which the design was to make the doors, and the ash drawer, fit as closely as possible, so that the fire might be regulated by the drawing out, or closing, of the latter; this is one of Spoor's, and there are many others similarly constructed in this respect, and in which, were the workmanship made a little more perfect, without any change of structure, all that Mr. Orr proposes from this arrangement would be accomplished.

In addition to the close doors, the patentee has grate bars placed under the fuel, resembling the revolving vertical dampers, or valves, used in some stoves, and consisting of two plates with openings, which may be made to coincide, or which may be closed by the unperforated parts. If we do not greatly err, such a grate will be obstructed by the coal, and choaked by the ashes. There may be enough in some of the individual arrangements pointed out, upon which to found and sustain a claim, but they are not made to stand alone, and it is not in our power to put them in a situation to do so.

24. For a *Portable Reflecting Baker;* Lorenzo B. Olmstead, Binghampton, Broom county, New York, January 20.

This tin baker is to be heated by means of a cylinder of sheet-iron, which is to contain ignited charcoal, and to pass vertically down through the back of the box which constitutes the baker. This latter is a kind of eight sided oven, the top being ridged like a roof, and the bottom in the same form inverted, the back circular, and the front, which lifts off, being straight; we mention these things because the peculiar form is claimed. The articles to be baked are put into pans, which stand on wires within the baker, and the fire being kindled, and the front reflector affixed in its place, we are assured that the desired operation will be "performed sooner than in any known oven or baker, with an immense saving of fuel."

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25. For *Cutting grooves in Corset rings of Bone, Ivory, &c., and also in other articles;* Charles Buckland, Middletown, Middlesex county, Connecticut, January 20.

The ring to be cut is placed upon the projecting end of a revolving mandrel, the frame of which is made to slide so that the ring may be brought up against a revolving saw, or cutter, which cuts the groove. The appendages for adapting it to the purpose to which it is applied, are represented and described, and the combination of the several parts constitutes the claim.

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26. For a *Thrashing Machine;* Eleazer Brown, Chenango, Broom county, New York, January 20.

This thrashing machine consists of a hollow cylinder about three feet in diameter; its length is not mentioned, but from the drawing, we should suppose it to be, at least, twelve feet. It stands horizontally in a frame, and within it revolves a shaft, which carries four, or any other number of rows of wooden beaters. The grain is fed into the cylinder through an opening in its side, near to one end, which is closed, the other being left open. On the shaft near the closed end are spiral fan leaves, which force a current of air through the cylinder. The patentee says that "the rapid motion of the shaft separates the grain, and the strong current of air driven through the cylinder by the fans, carries out the straw and grain." There is no claim made, the general construction being probably considered as new, which we believe it is.

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27. For a *Horse Power;* Samuel Newton, Dayton, Montgomery county, Ohio, January 20.

This horse power is one of that kind which receives its impulse from the walking of the horse, or other animal, upon an inclined floor forming a chain of slats, the patentee calls it the "Friction Obviator, or Double Chain Horse Power," in which is combined the joint application of two continuous, or endless, chains. The second of these endless chains consists of rollers connected by suitable straps, which sustain the movable floor by running upon a suitable railway under it, the part not so employed hanging down beneath the floor. After a full description of the apparatus a claim is made to "the particular manner of constructing the friction chain," &c. We could refer to several patents taken in the United States, for a perfectly similar contrivance, but will go farther back than any of these, and look in the second volume of the first series of the Repertory of Arts, p. 366,

where we find the same machine described and figured, having been patented in England, in January, 1795.

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28. For *Propelling Boats;* Philander Noble, Westfield, Hampden county, Massachusetts, January 20.

The patentee is, we apprehend, either a clock or watch maker, and knows very well that a spiral spring contained in a barrel, and made to act upon a fusee by means of a chain, is a sufficient maintaining power for his time keepers, and, by parity of reasoning, he concludes that it will answer equally well for boats. "This invention or improvement, consists in the application of the machinery of a clock to the purpose contemplated." The springs, we are informed, are to be wound up in the usual way; by means of the finger and thumb, we suppose. The plan is too absurd to reason about, and too contemptible even for ridicule.

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29. For a *Plough;* John P. Chandler and Peter Ranger, Wilton, Kennebec, Maine, January 20.

We have, for brevity's sake, called this a plough, but the patentees denominates it a "Machine for ploughing land," and indeed from its complexity it appears to require some such appellation. It has an axletree and two wheels, like a cart, with a frame somewhat like that of a cart body, sustaining a tongue to which to attach the horses, together with other appendages. Under this frame there are to be three ploughs abreast, all of which are to be managed, by means of levers and suspending chains, by a person seated on the machine; the ploughs being so suspended that they can be raised or lowered at pleasure. The claim made is to "the using of two or more ploughs at the same time, and with the same team; and also having the plough suspended so as to have the weight of it carried on wheels." The patentees might, probably, sustain a claim to their own mode of doing these things, but double ploughs have often been used, and wheeled ploughs are represented in the books, and are common in Europe.

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30. For an improvement in *Saddles and Horse Collars;* Ebenezer Hale, city of New York, January 20. (See Specification.)

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31. For a *Corn Sheller;* Warren Carpenter, New Castle, Mercer county, Pennsylvania, January 23.

A plank is to be slid up and down between two cheeks, grooved for that purpose; into each side of this plank iron pins are driven, which project out a short distance. The corn to be shelled is to be dropped in between this slide, and two pieces of plank near the lower end of the frame, which are borne up towards the slides by springs; these spring pieces of plank are armed with teeth, like the slide. The slide is to worked up and down by hand. The claim made is to "the particular structure, combination and arrangement of the respective parts."

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32. For a *Forcing Pump;* Benjamin Egbert, Lansing, Tompkins county, New York, January 23.

There is about as little to patent in this pump, as in most of those which obtain that nominal sanction. The claims made are to things either old, or worthless, and the whole construction is as far from meriting the name of an improvement, as can well be imagined. The claims made are to "the

base plate, the forked tube, the side rods, the cap piece, and the waste tubes, together with the mode of fastening the pump by the platform to the sink." The patentee might with about equal propriety claim his shoes, his two arms, his legs, his fur-cap, and his facial protuberence, together with the mode in which he seats himself at the table.

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33. For a *Cast metallic Funnel, to be used on Stove Pipes;* Ezra Ripley, city of Albany, New York, January 23.

Ferules are to be cast which pass into, or receive the ends of the pipe to be joined. These ferules are to be made ornamental, and there is a contrivance for attaching them to the pipe, by means of a wire, so as to keep them together. These ferules, the patentee says, "improve the beauty, increase the heat, and add strength and security."

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34. For an *Expanding Sulky Seat;* Orion H. Capron and Gardner Barton, Jr., Shaftsbury, Bennington county, Vermont, January 23.

The body of the sulky is to be made so that the seat and back shall consist of slats, or rods, which may slide between each other, so that it may lengthen out and accommodate two persons. The cushions must, of course, be made so as to double when the vehicle is in the sulky mood. The construction of the affair is described, but the mode of procedure is not claimed.

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35. For a *Machine for Packing Flour in Barrels;* Jonathan F. Barrett, Granville, Washington county, New York, January 23.

This is certainly a new, and, we think, a good machine. The flour to be pressed, runs into the barrel in a continuous stream, and the pressing commences at the bottom, and goes on until the barrel is filled. The barrel is placed on the bed of the press, and above it there is a vertical shaft, which is made to revolve by a drum and band, and is capable of rising and falling through the height of the barrel At the lower end of this shaft there is what is called a screw, but this essential part is very imperfectly described; it is nearly of the diameter of the interior of the barrel, and appears to be a transverse section, containing a single thread of a screw, and it has, of course, an opening from its upper to its lower side, through which flour may pass. The shaft, we suppose, must revolve in a direction tending to raise this section of a screw, and the bottom of it, forming a spiral inclined plane, presses upon the flour as it passes through the opening, having to operate upon thin successive strata only, and thus gradually rising to the top, when the packing is completed. The shaft is loaded with any amount of weight which may be found necessary, and there is appended to it the apparatus necessary for raising and lowering the shaft rapidly, when requisite. The claim made is to the employment of "a screw on the end of a weighted shaft," in the manner described.

The patentee says that about three minutes completes the pressing of a barrel of flour; the manual labour, however, not exceeding five seconds; that during the operation there is not any bursting of hoops, or pressing of flour out of the sides; that with a machine made to test the improvement, one man can readily pack, weigh, and nail off, about twenty barrels per hour.

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36. For an improvement in the *Construction of Wooden Bridges;* Stephen H. Long, Lieut. Col. U. S. Topographical Engineer Corps, January 23.

"The improvements claimed as new and useful consist in the application

and use of lattice, work, in the manner and of the description herein explained, for the purpose of imparting the requisite lateral stiffness to wooden bridges, in a manner more simple, economical and efficient than the means heretofore employed for that purpose; it being understood that *lateral* and *horizontal* stiffness, in contradistinction from *vertical* and *transverse* flexibilty, is the object of this invention."

This diagonal lattice-work framing, to be applied to the upper, or the lower, string pieces of bridges, is similar to the lattice-work truss frame, forming the sides of Town's bridges.

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37. For an improvement in the *Garden Hoe;* Adna Allen, Ramapo, Rockland county, New York, January 23.

This patent is taken for the manner of attaching the shank to the plate of the hoe, so as to render it secure from working loose. The plate or blade of the hoe, is perforated with a square hole; the shank is made to fit this hole, and has a collar formed on it which comes up against the plate; a second plate, like a washer, passes over the shank on the face of the hoe, and the whole is secured together by riveting; the shank is secured in the handle by a ferule, and fastened by a key driven through both. The claim is to "the collared shank, back plate, and rivets, viz: the collar on the shank, and the principle of attaching the back plate to the plate of the hoe."

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38. For a *Trap for Rats and other Animals;* Thomas Neil, Kirkersville, Licking county, Ohio, January 23.

This trap is so much like some others, that the claim to " the before described machine" appears to us to be a claim to that which had been made, if not described, long before. The trap is a long box, with a fall at each end, held up by a trigger very much like other triggers. In the centre of the box are placed two pieces of looking glass, to invite tenants to enter; an old and well known device.

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39. For *Constructing Coffins of Hydraulic Cement;* John White, Syracuse, Onondaga county, New York, January 23.

" The patentee says, "all that I claim under the foregoing specification, and wish to secure by letters patent, is the right of employing any hydraulic cements, materials, or mortars, not included in the before mentioned patents, in the making of receptacles for the dead; constructing the same in any form or shape which may be deemed convenient or desirable."

The "before mentioned patents" above referred to, are that granted Dayton, Hoyt, and White, on the 6th of June, 1835, and that to John White alone, on the 25th of July, 1835.

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40. For an improvement in the *Horse Collar;* John Hopkinson, Hamilton, Warren county, Ohio, January 23.

The specification tells how to make a patern by which to cut the leather, how to soak it and to tack it on to a cramping board, how to sew the parts together, and concludes by giving advice to stuff it, make the pad, and finish it off in the usual way; but it says nothing about a claim. There is a drawing, from which we cannot learn any thing, excepting that it represents a well looking horse collar.

Specification of a patent for an improvement in the manner of constructing Saddles and Horse Collars. Granted to EBENEZER HALE, *City of New York, January 20th*, 1836.

To all whom it may concern, be it known, that I, Ebenezer Hale, of the city, county and state of New York, have invented a new and useful improvement in the manner of constructing saddles and horse collars, in which I substitute that perfectly elastic article, air, as a stuffing, for the comparatively rigid and non-elastic materials heretofore employed, and I do hereby declare that the following is a full and exact description thereof.

The object in view is to interpose air between the hard materials, which form the foundation or more solid parts of saddles and horse collars, and those parts of them which bear upon the animal. In the general form or manner of making these articles, I do not profess to have made any improvement; all that I propose to do being merely to omit the ordinary stuffing on the bearing parts, and to cover them with leather, cloth, or other material rendered impervious to air by means of India rubber, or otherwise; so forming and fixing such covering as that when inflated, by means of a condensing syringe, the bearing parts will become distended, and assume the intended form. In some suitable part of the articles an opening furnished with a valve must be made for the purpose of attaching the syringe.

The manner in which the air-tight covering is to be attached, does not admit of, or require, any particular description, as it may be varied in numerous ways, and must be left to the judgment and fancy of the workman, who, if skilful, will be at no loss in this particular.

What I claim as my invention, is merely the substitution of air for other materials in forming a stuffing for the bearing parts of saddles and horse-collars.

EBENEZER HALE.

Specification of a patent for an improvement in the machinery for forming and hardening Rope. Granted to JOHN WHITEMAN, *city of Philadelphia, January 15th*, 1836.

To all whom it may concern, be it known, that I, John Whiteman, of the city of Philadelphia, in the state of Pennsylvania, have made an improvement in the machinery for manufacturing rope, by which it may be made of any desired length in a manner more convenient than any which has heretofore been practised; and I do hereby declare that the following is a full and exact description thereof.

A shaft or spindle is to be made to revolve horizontally, in a frame of suitable dimensions, its size depending upon the nature of the work to be performed by it. This shaft runs in boxes, bearings, or collars at each end. The front end where the spinning is performed, is made hollow in the manner of the spindle of the small flax wheel, admitting the rope which is to be twisted, to pass through it in the same way. In the eye or opening thus made, at the back of the bearing of the shaft, there is a small friction pulley inserted, to enable the rope to pass readily through the perforation in the spindle. There is a reel upon the spindle, upon which reel the rope is to be wound as it is made ready therefor. This reel is so constructed as to be capable of being thrown into and out of gear, with perfect facility; this may

be effected by means of a feather on the shaft, which is received in a notch made for the purpose, in the head of the reel. The throwing out of gear is done whenever the rope is to be wound upon the reel, which when disengaged from the feather, by being slid back, engages by means of suitable stops or projections, with a wheel and pinion, furnished with a winch, by which the reel may be turned back, and the rope wound upon it.

In order to wind the rope upon the reel I employ a sliding bar, having upon it teeth, forming it into a rack, into which teeth a pinion engages, by which the rack can be moved backwards and forwards. This sliding bar is placed on one side of the frame, parallel to the shaft, and extends from front to back of the machine; its motion is governed by suitable slides. The pinion by which it is moved is placed upon the vertical shaft at the back end of the machine, where it also bears against a friction roller acting on its smooth side. There is a fixed snatch block upon the front post of the machine, and a second snatch block on the inside of the slide towards the spindle, and when the rope is to be wound upon the reel it is first passed round the pulleys of these blocks, when the reel may be turned back, and the rope distributed upon the reel by means of the rack and pinion. For a more perfect understanding of the arrangement of the apparatus by which this is effected, I refer to the drawing, with written references thereto, deposited in the patent office in conformity with the requirements of the law in that case made and provided.

Although I have in the foregoing description spoken of using one spindle only, it is to be distinctly understood that I intend to combine three, or any other number which I may prefer of such spindles, constructed and operating upon the same principle, in the same machine.

What I claim as my invention in the machinery for making ropes and cordage is the manner of distributing the rope, as within described, upon a reel placed upon a shaft or spindle, driven by any of the ordinary means of giving motion to shafts for spinning; which reel is so constructed as to engage and disengage in the manner, and for the purposes herein set forth, whether the same be applied to only one, or to a greater number of spindles in the same frame.

JOHN WHITEMAN.

Progress of Physical Science.

Dissected Battery and Standard Battery of Professor Daniel.

For the purpose of ascertaining the influence exerted by the different parts of the voltaic battery, in their various forms of combination, Professor Daniel, contrived an apparatus, which he designates by the name of *the dissected battery*, and which consists of ten cylindrical glass cells, capable of holding the fluid electrolytes, in which two plates of metal are immersed; each plate communicating below, by means of a separate wire, which is made to perforate a glass stopper closing the bottom of the cell, with a small quantity of mercury, contained in a separate cup underneath the stopper, and with which electric communications may be made at pleasure through other wires passing out of the vessel on each side.*

* The arrangement seems to us much inferior in convenience, to the battery devised for similar objects, by Professor Henry of Princeton, and described in the Amer. Philos. Trans. Vol. 5, Part 2. COM. PUB.

A series of experiments performed with the dissected battery is next described; illustrating, in a striking manner, the difference of effects with relation to the quantity and the intensity of the electric current, consequent on the different modes of connecting the elements of the battery: the former property being chiefly exhibited when the plates of the respective metals are united together so as to constitute a single pair; and the latter being exalted when the separate pairs are combined in alternate series. The influence of different modifications of these arrangements, and the effects of the interposition of pairs in the reverse order, operating as causes of retardation, are next inquired into.

In the course of these researches, the author, being struck with the great extent of negative metallic surface over which the deoxidating influence of the positive metal appeared to manifest itself, as is shown more especially in the cases where a large sheet of copper is protected from corrosion by a piece of zinc or iron of comparatively very small dimensions, was induced to institute a more careful examination of the circumstances attending this class of phenomena; and was thus led to discover the cause of the variations and the progressive decline of the power of the ordinary voltaic battery, one of the principal of which is the deposit of the zinc on the platina [or copper] plates; and to establish certain principles from which a method of counteracting this evil may be derived. The particular construction which he devised for the attainment of this object, and which he denominates the *constant battery*, consists of a hollow copper cylinder, containing within it a membranous tube formed by the gullet of an ox, in the axis of which is placed a cylindrical rod of zinc. The dilute acid is poured into the membranous tube from above by means of a funnel, and passes off, as occasion requires, by a siphon tube at the lower part; while the space between the tube and the sides of the copper cylinder is filled with a solution of sulphate of copper, which is preserved in a state of satuation by a quantity of this substance suspended in it by a collander, allowing it to percolate in proportion as it is dissolved. Two principal objects are accomplished by this arrangement; first, the removal out of the circuit of the oxide of zinc, the deposite of which is so injurious to the continuance of the effect of the common battery; and, secondly, the absorption of the hydrogen evolved upon the surface of the copper, without the precipitation of any substance which would tend to counteract the voltaic action of that surface. The first is completely effected by the suspension of the zinc rod in the interior membranous cell, into which the fresh acidulated water is allowed slowly to drop, in proportion as the heavier solution of the oxide of zinc is withdrawn from the bottom of the cell by the siphon tube. The second object is attained by charging the exterior space surrounding the membrane with a saturated solution of sulphate of copper, instead of diluted acid; for, on compleating the circuit,* the electric current passes freely through this solution, and no hydrogen makes its appearance upon the conducting plate, but a beautiful pink coating of pure copper is precipitated upon it, and thus perpetually renews its surface.

When the whole battery is properly arranged and charged in this manner, it produces a perfectly equal and steady current of electricity for many hours together. It possesses also the further advantages of enabling us to get rid of all local action by the facility it affords of applying amalgamated zinc; of allowing the replacement of the zinc rods at a very trifling expense; of securing the total absence of any wear of the copper; of requiring no employment of nitric acid, but substituting in its stead materials

of greater cheapness, namely, sulphate of copper, and oil of vitriol; the total absence of any annoying fumes; and lastly, the facility and perfection with which all metallic communications may be made and their arrangements varied. Abstract of Proceedings Royal Soc. in Lond. and Edin. Phil. Mag., May.

On the general Magnetic relations and characters of the Metals. By Professor FARADAY.

In a paper in the number of the London and Edinburgh Philos. Mag. for March, Prof. Faraday has a paper bearing the title just quoted. He states that general views had long since led him to the opinion, that all the metals are magnetic, in the same manner as iron, though not at common temperatures; iron and nickel being no more exceptions to the magnetic relations of metals in general, than mercury is in their relations to heat. He reduced the temperatures of the following metals to 60 or 70° below zero of Fahrenheit's scale, by the evaporation of sulphurous acid, but could perceive no indications of the development of magnetism in them. Arsenic, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, lead, mercury, palladiam, platinum, silver, tin, zinc. Plumbago was subjected to the same result. Prof. Faraday also investigated the temperature at which nickel loses its power of becoming magnetic, with a view to compare it with the corresponding point, for iron which is worked at an orange heat. This point was found to be, for nickel, between 630 and 640° Fah. Steel loses its permanent magnetic power suddenly below the boiling point of almond oil; between this temperature and an orange heat it acts as soft iron. The temperature at which polarity was destroyed, appeared to vary with the hardness and condition of the steel. A natural magnet, or loadstone, retained its polarity at a temperature above that at which steel lost the same power, losing it when visibly red in the dark. On the contrary, the same loadstone lost the action similar to soft iron, of becoming magnetic by induction, at a lower temperature than steel. The same results were found when the loadstone of which the magnetism had been destroyed by heat, had its polarity destroyed on cooling, by touching with an artificial magnet. Abstract from Lond. and Ed. Philos. Mag.

Ice formed at or near the bottom of Streams.

The formation of ice in such situations is thus explained by M. ARAGO.*—1st. The circumstance already adverted to, that in streams the rapidity of the current, especially in falls, carries down the colder water of the surface, and mixes it with that at the bottom; so that the deepest part here is colder than in still water.

2d. The rough and pointed nature of the substances at the bottom favour the depositon of ice, in the same manner as similar asperities form the nuclei foı crystalization in solutions of salts.

3d. The motion of the stream near the bottom is retarded by friction; thus there is less impediment to the formation of the spiculæ of ice.

Mr. Farquharson, in a recent investigation of this subject,† admits that these causes are all in action, but denies their *sufficiency* to account for the *entire* phenomena.

He assumes the cause to be, that *heat radiates through water;* that the same laws prevail with respect to the influence of the state of the *surface* in promoting radiation, in water as in air. Consequently, the *rough* surface

* Annuaire des bureau des Long. &c. 1833. † Royal Soc. Trans. 1835, Part I.

of the stones, gravel, &c., at the bottom, enables them to radiate heat, and cool fastest, and there the ground-gru forms.

A writer in a recent number of the London Magazine of Popular Science, after showing the contrariety of the fact assumed by Mr. Farquharson, with the experiments of Melloni, offers the following suggestions:

"There is another distinctive circumstance not adverted to either by Mr. Farquharson or other inquirers, but which appears to us the most efficacious of all others to the production of the phenomena. The adjacent ground, and the bed of the river, are first cooled down by a frost to a lower degree than the water; and thus the bottom will be rather colder than the incumbent strata of water, even in the rapids, where it is soonest brought to an equilibrium of temperature; and this cooling down of the whole adjacent ground, of course, goes on most rapidly under a clear sky, by radiation at night; the ground in the bed of the river acquiring the same temperature, or nearly so, by lateral conduction.

Now solid rock is a much better *conductor* of heat than loose gravel, or sand, &c., and the former, it appears, composes the bed of the rapids, the latter of the pools. The former, therefore, conducts quickly away the slight excess of temperature in the running water of the rapids, and converts it into ground-gru. The latter conducts more slowly, and has also a greater degree of temperature to carry off; thus—the gru does not form.

Height of Waves. A writer in the Nautical Magazine (Eng.) concludes from his observation of waves after a storm in the Atlantic, that the total height was not less than fifty feet, since "a horizontal line drawn from the apex of the loftiest wave to the ship, would have intersected the main mast about half way from the deck." He gives, further, an estimate founded on the observation which follows:

"A large ship, which was for a short time in company with a frigate we were on board of, was lost sight of at intervals when she fell into the trough of the sea, and only entirely visible when both vessels happened to be on the ridge of the respective waves which bore them up: this alternation of appearance and disappearance continued until we had approached within less than a mile of the ship, for at about that distance, when one enormous wave intervened, she was hid for the last time during the approach. Her elevation from the water-line to her mast-head could not have been less than ninety feet. When both ships were depressed, they were invisible to each other; and when one was on the ridge of a wave, and the other in the trough, part of the masts of the latter were visible to the former.

The distance between the ships, and the relative proportions of the objects, should be kept in mind:—a ship compared to one of those billows would be as a mere speck, allowing the breadth of the wave to be half a nautical mile, or 3040 feet; and if we admit the wave to be only twenty feet, the ship's hull thirteen, and five for the height of the observer, the eye, when the ship was on the ridge of the wave, would be elevated thirty-eight feet above the trough in which the other was situated."

Steel for Magnets. Mr. R. Knight concludes that open-grained blistered steel is well fitted for powerful magnets; that closing the grain by heating and hammering it, though it should still remain carbonised, greatly injures it, and that the subsequent action of heat, in opening it, though it much improves the quality, does not restore it to the same openness of grain that it had at first. Trans. Lond. Soc. Arts.

Lines of equal magnetic dip in Great Britain. Mr. R. W. Fox, of Falmouth, has made a number of observations of the magnetic dip and in-

tensity in England and Ireland, and lays down from his observations the approximate positions of the lines of equal dip. A remarkable break occurs in these lines in passing from Ireland to England, the line which passes near Dublin, for example, being found on the English coast near the extremity of North Wales, or to the south of the position on the Irish side of the channel. Mr. Fox attributes an important effect on the dip and intensity to trap-dykes, and to basaltic formations; and considers that the usual elevations and depressions of a country modify both of those magnetic elements, elevations increasing the former of them. Third. Ann. Rep. Cornwall Polytech. Soc. 1835.

Temperature of the muscles in Man. By the use of thermo-magnetic arrangements, M. Becquerel has determined the temperature of the muscles in man to be 98.2° Fah. The subjects of experiment were three young men in healthy condition. Ann. de Chim. et Phys. vol. LIX.

Progress of Practical and Theoretical Mechanics and Chemistry.

On the application of the Hot Blast in the manufacture of Cast-iron. By Thomas Clarke, *M. D., Professor of Chemistry in Marischall College, Aberdeen.*

(Read before the Royal Society of Edinburgh, March, 1835.)

Among persons interesting themselves in the progress of British manufactures, it can scarce fail to be known, that Mr. Neilson of Glasgow, manager of the Gas Works in that city, has taken out a patent for an important improvement in the working of such furnaces as, in the language of the patent, "are supplied with air by means of bellows, or other blowing apparatus." In Scotland, Mr. Neilson's invention has been extensively applied to the making of cast-iron, insomuch that there is only one Scotch iron-work where the invention is not in use, and in that work, apparatus is under construction to put the invention into operation. Apart from the obvious importance of any considerable improvement in the manufacture of so valuable a product as cast-iron, the invention of Mr. Neilson would merit attention, were it only for the singular extent of the improvement effected, compared with the apparent simplicity—I had almost said inadequacy—of the means employed. Having therefore, by the liberality of Mr. Dunlop, proprietor of the Clyde Iron-Works, where Mr. Neilson's invention was first put into operation, obtained full and free access to all information regarding the results of trials of the invention in those works, on the large scale of manufacture, I cannot help thinking that an authentic notice of these results, together with an attempt to explain the cause of them, will prove acceptable to the Royal Society of Edinburgh. And that these results, as well as the cause of them, may be set forth with clearness, I shall advert,

1st. To the process of making iron, as formerly practised.

2d. To Mr. Neilson's alteration on that process.

3d. To the effect of that alteration.

4th. To the cause of that effect.

I. In proceeding to advert to the process of making cast-iron, as formerly practised, it cannot here be necessary to enter into much detail in explanation of a process, long practised and extensively known, as this has

been; nor, indeed, shall I enter into detail, farther than, to the general scientific reader, may be proper to elucidate Mr. Neilson's invention.

In making cast-iron, then, the materials made use of were three,—the ore, the fuel, the flux.

The ore was clay iron-stone, that is to say, carbonate of iron, mixed, in variable proportions, with carbonates of lime, and of magnesia, as well as with aluminous and silicious matter.

The fuel made use of at Clyde Iron-works, and in Scotland, generally, was coke, derived from splint-coal. During its conversion into coke, this coal underwent a loss of 55 parts in the 100, leaving 45 of coke. The advantage of this previous convertion consisted in the higher temperature produced by the combustion of coke, in consequence of none of the resulting heat disappearing in the latent form, in the vapours arising from the coal, during its convertion into coke.

The flux was common limestone, which was employed to act upon the aluminous and silicious impurities of the ore, so as to produce a mixture more easy to melt than any of the materials of which it was made up, just as an alloy of tin and lead serves as a solder, the resulting alloy being more easy to melt than either the lead or the tin apart.

These three materials—the ore, the fuel, and the flux—were put into the furnace, near the top, in a state of mixture. The only other material supplied was air, which was driven into the furnace by pipes from blowing apparatus, and it entered the furnace by nozzles, sometimes on two opposite sides of the furnace, sometimes on three, sometimes, but rarely, on four. The air supplied in this manner entered near the bottom of the furnace, at about forty feet from the top, where the solid materials were put in. The furnace, in shape, consisted, at the middle part, of the frustums of two cones, having a horizontal base common to both, and the other and smaller ends of each prolonged into cylinders, which constituted the top and bottom of the furnace.

The whole of the materials put into the furnace, resolved themselves into gaseous products, and into liquid products. The gaseous products, escaping invisibly at the top, included all the carbonaceous matter of the coke, probably in the form of carbonic acid, except only the small portion of carbon retained by the cast-iron. The liquid products were collected in the cylindrical reservoir, constituting the bottom of the furnace, and there divided themselves into two portions, the lower and heavier being the melted cast-iron, and the upper and lighter being the melted slag, resulting from the action of the fixed portion of the flux upon the impurities of the fuel and of the ore.

II. Thus much being understood in regard to the process of making cast-iron, as formerly practised, we are now prepared for the statement of Mr. Neilson's improvement.

This improvement consists essentially in heating the air in its passage from the blowing apparatus to the furnace. The heating has hitherto been effected by making the air pass through cast-iron vessels, kept at a red heat. In the specification of the patent, Mr. Neilson states, that no particular form of heating apparatus is essential to obtaining the beneficial effect of his invention; and, out of many forms that have been tried, experience does not seem to have yet decided which is best. At Clyde Iron-Works, the most beneficial of the results that I shall have occasion to state, were obtained by the obvious expedient of keeping red-hot the cast-iron cylindrical pipes conveying the air from the blowing apparatus to the furnace.

III. Such being the simple nature of Mr. Neilson's invention, I now proceed to state the effect of its application.

During the first six months of the year 1829, when all the cast-iron in Clyde Iron-Works was made by means of the cold blast, a single ton of cast-iron required for fuel to reduce it, 8 tons 1¼ cwt. of coal, converted into coke. During the first six months of the following year, while the air was heated to near 300° Fah., one ton of cast-iron required 5 tons 3¼ cwt. of coal, converted into coke.

The saving amounts to 2 tons 18 cwt. on the making of one ton of cast-iron; but from that saving comes to be deducted the coals used in heating the air, which were nearly 8 cwt. The nett saving was thus 2½ tons of coal on a single ton of cast-iron. But during that year, 1830, the air was heated no higher than 300° Fah. The great success, however, of those trials, encouraged Mr. Dunlop, and other iron-masters, to try the effect of a still higher temperature. Nor were their expectations disappointed. The saving of coal was greatly increased, insomuch that, about the beginning of 1831, Mr. Dixon, proprietor of the Calder Iron-Works, felt himself encouraged to attempt the substitution of raw coal for the coke before in use. Proceeding on the ascertained advantages of the hot blast, the attempt was entirely successful; and, since that period, the use of raw coal has been extended so far as to be adopted in the majority of the Scotch Iron-Works. The temperature of the air under blast had now been raised so as to melt lead, and sometimes zinc, and therefore, was above 600° Fah., instead of being only 300°, as in the year 1830.

The furnace had now become so much elevated in temperature, as to require water around the nozzle of the blow pipes, a precaution borrowed from the finery-furnaces, wherein cast-iron is converted into malleable, but seldom or never employed where cast-iron is made by means of the cold blast. What is called the *Tweer*, is the opening of the furnace to admit the nozzle of the blow pipe. This opening is of a round funnel-shape, tapering inwards, and it used always to have a cast-iron lining, to protect the other building materials, and to afford them support. This cast-iron lining was just a tapering tube nearly of the shape of the blow pipe, but large enough to admit it freely. Now, under the changes I have been describing, the temperature of the furnace near the nozzles, is such as to risk the melting of the cast-iron lining, which, being essential to the *tweer*, is itself commonly called by that name. To prevent such an accident, an old invention called the *water-tweer* was made available. The peculiarity of this tweer consists in the cast-iron lining already described being cast hollow instead of solid, so as to contain water within, and water is kept there continually changing as it heats, by means of one pipe to admit the water cold, and another to let the water escape when heated.*

During the first six months of the year 1833, when all these changes had been fully brought into operation, one ton of cast-iron was made by means of 2 tons 5¼ cwt. of coal, which had not previously to be converted into coke. Adding to this 8 cwt. of coal for heating, we have 2 tons 13¼ cwt. of coal required to make a ton of iron; whereas, in 1829, when the cold blast was in operation, 8 tons 1¼ cwt. of coal had to be used. This being almost exactly three times as much, we have, from the change of the cold

* An incidental advantage attended the adoption of the water-tweers, inasmuch as these made it practicable to lute up the space between the blow-pipe nozzle and the tweers, and thus prevent the loss of some air that formerly escaped by that space, and kept up a bellowing hiss, which, happily, is now no longer heard.

blast to the hot, combined with the use of coal instead of coke, *three times as much iron made from any given weight of splint coal.*

During the three successive periods that have been specified, the same blowing apparatus was in use; and not the least remarkable effect of Mr. Neilson's invention, has been the increased efficacy of a given quantity of air in the production of iron. The furnaces at Clyde Iron-Works, which were at first three, have been increased to four, and, the blast machinery being still the same, the following were the successive weekly products of iron during the periods already named, and the successive weekly consumption of fuel put into the furnace, apart from what was used in heating the blast:

	Tons.	Tons.	Tons.
In 1829, from 3 furnaces,	111	Iron from 403	Coke from 888 Coal.
In 1830, from 3 furnaces,	162	Iron from 376	Coke from 836 Coal.
In 1833, from 4 furnaces,	245	Iron	from 554 Coal.

Comparing the product of 1829 with the product of 1833, it will be observed that the blast, in consequence of being heated, has reduced more than double the quantity of iron. The fuel consumed in these two periods we cannot compare, since, in the former, coke was burned, and, in the latter, coal. But on comparing the consumption of coke in the years 1829 and 1830, we find, that although the product of iron in the latter period was increased, yet the consumption of coke was rather diminished. Hence the increased efficacy of the blast appears to be not greater than was to be expected, from the diminished fuel that had become necessary to smelt a given quantity of iron.

On the whole, then, the application of the hot blast has caused the same fuel to reduce three times as much iron as before, and the same blast twice as much as before.

The proportion of the flux required to reduce a given weight of the ore, has also been diminished. The amount of this diminution, and other particulars, interesting to practical persons, will appear on reference to a tabular statement supplied by Mr. Dunlop, and printed as an appendix to this paper. Not further to dwell on such details, I proceed to the last division of this paper, which is,

IV. To attempt an explanation of the foregoing extraordinary results.

Subsidiary to this attempt, it is necessary to discriminate between the quantity of fuel consumed and the temperature produced. For instance, we may conceive a stove to be kept at the temperature of 500° Fah., and lead to be put into such a stove for the purpose of being melted. Then, since the melting point of lead is more than 100° higher, it is evident that whatever fuel might be consumed in keeping that stove at the temperature of 500°, the fuel is all consumed to no purpose, so far as regards the melting of lead, in consequence of deficiency in the temperature. In the manufacture of cast-iron likewise, experience has taught us, that a certain temperature is required in order to work the furnace favorably, and all the fuel consumed so as to produce any lower degree of temperature, is fuel consumed in vain. And how the hot blast serves to increase the temperature of a blast furnace, will appear on adverting to the relative weights of the solid and of the gaseous materials made use of in the reduction of iron.

As nearly as may be, a furnace, as wrought at Clyde Iron-Works in 1833, had two tons of solid materials an hour put in at the top, and this supply of two tons an hour was continued for twenty-three hours a day, one half-hour every morning, and another every evening, being consumed in letting off the iron made. But the gaseous material—the hot air—what

might be the weight of it? This can easily be ascertained thus: I find, by comparing the quantities of air consumed at Clyde Iron-Works, and at Calder Iron-Works, that one furnace requires of hot air, from 2,500 to 3,000 cubical feet in a minute. I shall here assume 2,867 cubical feet to be the quantity; a number that I adopt for the sake of simplicity, inasmuch as, calculated at an avoirdupois ounce and a quarter, which is the weight of a cubical foot of air at 50° Fah., these feet correspond precisely with 2 cwt. of air a minute, or *six tons an hour*. Two tons of solid material an hour, put in at the top of the furnace, can scarce hurtfully effect the temperature of the furnace, at least in the hottest part of it, which must be far down, and where the iron, besides being reduced to the state of metal, is melted, and the slag, too, produced. When the fuel put in it at the top is coal, I have no doubt that, before it comes to this far-down part of the furnace—the place of its useful activity—the coal has been entirely coked; so that, in regard to the fuel, the new process differs from the old much more in appearance than in essence and reality. But if two tons of solid material an hour, put in at the top, are likely to effect the temperature of the hottest part of the furnace, can we say the same of six tons of air an hour, forced in at the bottom near that hottest part? The air supplied, is intended, no doubt, and answers, to support the combustion; but this beneficial effect is, in case of the cold blast, incidentally counteracted by the cooling power of six tons of air an hour, or 2 cwt. a minute, which, when forced in at the ordinary temperature of the air, cannot be conceived otherwise than as a prodigious refrigeratory passing through the hottest part of the furnace, and repressing its temperature. The expedient of previously heating the blast obviously removes this refrigeratory, leaving the air to act in promoting combustion, without robbing the combustion of any portion of the heat it produces.

Such, I conceive, is the palpable, the adequate, and very simple explanation of the extraordinary advantages derived in the manufacture of cast-iron, from heating the air in its passage from the blowing apparatus to the furnace.

Marischal College, Aberdeen, Jan. 10, 1835.

APPENDIX.

The blowing-engine has a steam-cylinder of forty inches diameter, and a blowing cylinder of eight feet deep and eighty inches diameter, and goes eighteen strokes a minute. The whole power of the engine was exerted in blowing the three furnaces, as well as in blowing the four, and in both cases there were two tweers of three inches diameter to each furnace. The pressure of the blast was $2\frac{1}{2}$ lb. to the square inch. The fourth furnace was put into operation after the water-tweers were introduced, and the open spaces round the blow-pipes were closed up by luting. The engine then went less than eighteen strokes a minute, in consequence of the too great resistance of the materials contained in the three furnaces to the blast in its passage upwards.

Materials constituting a Charge.

		cwt.	qrs.	lbs.
1829,	Coke	5	0	0
	Roasted Ironstone,	3	1	14
	Limestone,	0	3	16
1830,	Coke,	5	0	0
	Roasted Ironstone,	5	0	0
	Limestone,	1	1	16
1833,	Coal,	5	0	0
	Roasted Ironstone,	5	0	0
	Limestone,	1	0	0

Table showing the weight of Cast-Iron produced, and the average weight of Coals made use of, in producing a ton of Cast-Iron, at Clyde Iron-Works, during the years 1829, 1830, and 1833, the Blowing-Engine being the same.

COKE AND COLD AIR.				COKE AND HEATED AIR.				COAL AND HEATED AIR.			
1829	Weekly product of Cast-Iron by three Furnaces.		Average of Coals used to 1 ton of Cast-Iron.	1830	Weekly product of Cast-Iron by three Furnaces.		Average of Coals used to 1 ton of Cast-Iron.	1833	Weekly product of Cast-Iron by Four Furnaces.		Average of Coals used to 1 ton of Cast-Iron.
	Tons Cwt Qrs.		Tons Cwt Qrs.		Tons Cwt Qrs.		Tons Cwt Qrs.		Tons Cwt Qrs.		Tons Cwt Qrs.
Jan. 7	137 18 2		8 12 1	Jan. 6	176 10 2		5 2 2	Jan. 9	375 8 0		2 12 3
14	148 2 0		6 9 2	13	181 12 2		5 0 2	16	267 18 0		2 4 2
21	148 8 2		6 11 3	20	172 5 2		5 0 2	23	270 7 2		2 3 1
28	138 9 2		7 0 2	27	178 7 0		4 19 0	30	250 9 0		2 4 0
Feb. 4	125 13 0		7 12 1	Feb. 3	164 8 0		5 4 0	Feb. 6	265 3 2		2 1 0
11	136 19 0		7 13 1	10	172 12 0		5 4 0	13	202 10 0		2 4 3
18	139 16 2		7 11 3	17	163 9 0		5 9 0	20	257 1 0		2 4 3
25	105 12 2		7 10 0	24	170 1 0		5 3 0	27	264 0 0		2 5 1
Mar. 4	101 8 1		7 17 2	Mar. 3	154 19 0		5 10 3	Mar. 6	234 13 0		2 5 2
11	111 2 0		8 2 2	10	154 16 0		5 9 2	13	238 7 2		2 7 1
18	114 10 0		7 6 2	17	151 8 2		5 9 3	20	205 13 0		2 10 2
25	110 14 0		8 8 1	24	163 17 0		5 5 1	27	217 14 0		2 2 3
Ap. 1	111 4 0		8 7 2	31	163 8 2		5 11 0	Ap. 3	220 7 0		2 14 2
8	107 7 0		8 3 0	Ap. 7	147 10 0		5 7 0	10	280 9 2		2 0 3
15	91 12 2		8 15 0	14	154 9 2		5 2 0	17	304 7 0		1 17 3
22	85 13 0		9 13 0	21	163 4 0		4 19 9	24	248 12 2		2 3 0
29	91 14 2		9 6 2	28	148 12 2		5 4 0	May 1	245 7 2		2 6 0
May 6	92 7 2		8 8 2	May 5	162 10 2		5 2 2	8	200 17 0		2 8 0
13	94 6 0		9 2 1	12	149 13 0		5 3 2	15	246 4 2		2 5 3
July 8	88 4 2		8 16 3	19	162 4 0		5 5 0	22	219 1 2		2 6 0
15	91 13 0		8 5 0	26	165 7 2		4 18 3	29	231 2 0		2 8 0
22	97 2 0		8 2 1	June 2	160 4 0		5 2 2	June 5	235 16 0		2 6 2
29	104 15 2		7 10 2	9	157 17 0		5 1 0	12	232 10 0		2 7 1
Aug. 5	106 17 2		7 7 2	16	164 0 0		4 17 3	19	271 1 2		2 1 0
12	93 1 0		8 6 0	23	149 3 0		4 18 0	26	262 3 2		2 3 1
19	113 7 0		8 18 2	30	162 16 2		4 16 3	4 w. 30	122 16 0		2 5 1
	2878 18 0		309 19 0		4215 6 0		134 6 2		6390 3 0		38 18 3
Average.	110 14 2		8 1 1		162 2 2		5 3 1		245 0 0		2 5 1

The correspondent by whom we have been obligingly favored with the preceding paper, makes himself the following remarks on the subject of which it treats.—ED. M. M.

"The best application of the hot blast that I have yet seen, is at the Wilsonton Iron-Works, near Lanark and Whitburn. At these works the heated air is never at a *lower* temperature than the melting point of lead (612°). This is readily *tested* by inserting a small bar of lead into an opening in the pipe for the purpose, a little way before it enters the furnace; the lead is *instantly* melted. When in good working order, zinc is fused (700°) in the same way. The air is heated in passing through a series of iron-pipes of *small* diameter, fixed upright in a brick oven, and kept at a red heat; the heated air entering the furnace by *four tweers*. 'The Condie pipes,'—so called from Mr. John Condie, the manager of the Wilsonton Iron-Works, and late the Calder—last much longer than the ill-arranged heating-apparatus (with pipes of large diameter) at the Clyde Iron-Works, and effect a much greater saving in fuel.

The *raw coal* when used as the fuel, has the disdvantage of soon filling the furnace, and is also found to produce an inferior quality of iron, to that made by use of coke. It is, therefore not unlikely to be soon, generally, given up." Lond. Mech. Mag.

British Association for the Advancement of Science.

Section of Mechanics applied to the Arts.

The great press of business in the Physical Section rendered it necessary to institute a sub-section for the Useful Arts, and the increasing interest felt in the subject of Civil Engineering, induced the Association to establish it as a permanent Section of their body, under the designation of *Mechanical Science applied to the Arts.* Of this sub-section Mr. Rennie was appointed President, and Dr. Lardner, Vice-President. Mr. Eaton Hodgekinson reported the result of certain experiments which he had communicated to the Association at the three previous meetings. He also gave the result of some very curious experiments in the Fractures of Wires in different states of tension.

M. Mallet read a paper on the Fracture of bars of Cast Iron.

Mr. Pritchard exhibited an Achromatic Microscope, made by him on the principles published in his works, in which the angular aperture of the object glasses exceeds any that have yet been produced.

Mr. Ettrick read an account of a Mariners' Compass, which by two adjustments, caused the cardinal points on the card to coincide with the corresponding points of the horizon, whereby the mariner is saved the trouble of allowing for the variation in steering, and the expense of purchasing variation plates. It was effected by securing the needle upon the card by moveable clamps, and adjusting such needle for the magnetic variation of Greenwich, with a contrivance for changing it in places having a different local variation.

Mr. Ettrick read an account of certain improvements in Steam Engines, for rendering available the steam of high pressure boilers, which is below the pressure of the atmosphere, by permitting the high pressure steam to pass off into the atmosphere, and the steam of low pressure to pass off into a condenser by a secondary slide. He also gave a report of certain improvements in securing the seams of boilers, by longitudinal, instead of the present circular, clenches, and described a machine for drilling boiler plates, as rapidly as they can be punched by the punching machine. He also gave an account of certain improvements in the astronomical clock.

Mr. Russel read a paper on the Solids of Least Resistance, with reference to the construction of steam vessels, and detailed several experiments to prove, that the object would be best attained by giving a parabolic form to the prow.

Mr. Taylor, the treasurer of the British Association, made a communication respecting the monthly reports of the *duty* of steam-engines, employed in draining the mines of Cornwall; and observed, that he had found at this and other meetings of the Association, considerable interest to be expressed, with regard to this mode of recording the actual effect produced by the consumption of a given quantity of fuel, and recommended the subject to the notice of engineers in general. These reports gave the means of comparing one engine with another in the district; they also afforded an historical view of the progress of improvement in this important machine; and they had contributed largely to that improvement, by the emulation and attention excited by them, in the persons who had the charge of constructing and managing the engines. Mr. Taylor testified to the accuracy of the duty reports, declaring that he had compared them with the account books kept at the different establishments, and found that the results of both coincided.

Dr. Lardner then addressed the section on the subject of Rail-roads.

Professor Stevely described a Self-registering Barometer.

Mr. John Isaac Hawkins explained, on a model, a safe mode of Turning Corners on a Rail-road by means of Mr. Saxton's Differential Pulley. He also read an account of an interesting experiment on the evaporation of water.

Mr. Cheverton read a paper on Mechanical Sculpture, or the production of busts and other works of art by machinery, and illustrated the subject by specimens of busts, and a statue in ivory, which were laid on the table. They were beautifully executed, and excited universal admiration. The machine was invented by Mr. J. I. Hawkins, and perfected by himself.

Mr. Grubb made some observations on an improved method for Mounting an Equatorial Instrument adopted by E. J. Cooper, M. P., in his private observatory. Mr. Cooper bore testimony to the excellence of the instrument, and to Mr. Grubb's talents and zeal in scientific improvements.

Lieut. Denham, R. N. made some observations on the Vibratory Effects of Rail-roads; and a long discussion ensued between Dr. Lardner and Mr. Vignolles on the advantages arising from acclivities in rail-roads.

Rep. Pat. Invent.

Instance of human effort.—Six Days' Sawing. A pair of sawyers in the yard of Messrs. Paul and Co., timber-merchants, Broad street, Golden-square, executed the following quantity of labor in sixty working-hours, in six days, beginning about 8 A. M. on Monday, the 25th, and ending about four P. M. on the following Saturday, the 30th of January, in the present year.

They sawed through an area of 3068 square feet of American Pine, along a line whose total length was 1726 feet. In doing this, they raised the saw 124,272 times, and as this tool weighed 30 lbs., they lifted an actual weight of 3,728,160 lbs. But this amount of labour was not more than one-third the actual exertion expended; for to overcome the friction, in pulling up the saw through the kerf, and forcing it down again through the wood, at least two-thirds more was necessary; the total labour, therefore, was equal to lifting 11,184,480 lbs. to the height of the stroke, and as this was four feet, there was 44,737,920 lbs.=19,958 tons. 18 cwt. raised one foot high, in 60 hours, which is 12,427 lbs.=5 tons, 11 cwt. raised one foot high, per minute, by the two men, and 2 tons, 15½ cwt. per man, 1 foot high per minute. Lond. Mag. Pop. Science.

Improvements in the manufacture of Beet Root Sugar. In a memoir addressed to the Society for the encouragement of National Industry in France, M. Desormes alleges that the use of animal charcoal in grains for filtering the sirop, and the employment of large quantities of this decolorizing principle, is the greatest improvement recently made in the manufacture of sugar from beets. The charcoal is heated in tin plates, and finally on a cast-iron plate nearly red hot, by which the vegetable matters absorbed by it are decomposed, and the material is again fit for use in removing the color from the sirop. He states the amount of bone charcoal which may be profitably used, as high as one hundred and fifty per cent. of the weight of sugar to be obtained. Bull. Soc. d'encouragement.

Lime water used in the dressing of Wool. A patent has been taken out in England for the use of an imperfect soap formed by mixing three parts, by bulk, of a saturated solution of lime in water, with any of the oils used in the preparation and manufacture of wool. The patentee states that the substitution of this composition for oil, will save nearly three-fourths of the oil now used, and much of the soap required in cleansing.

Rep. Pat. Invent. April.

Analysis of German Silver. A recent analysis of this compound, by Mr. J. D. Smith, gave copper, 42.1, zinc 12.5, nickel 13.2, cobalt 2.4 from 70 grains of the alloy. Lond. and Edin. Philos. Mag. Jan.

Progress of Civil Engineering.

Observations on the Classification and Details of the Architecture of the Middle Ages. By E. B. Lamb, Esq. Architect.

The study of ancient architecture is fraught with difficulties: one book is examined after another; but, unless you refer to ancient buildings, you seek in vain for a brief and clear classification of the styles, dates, and systems, so essential to the beginner. Many, and voluminous, indeed, are the essays on some particular parts of Gothic architecture; but very few can give satisfactory information, fit for the practical purposes of the art. This is only to be acquired by a close examination of our ancient buildings; and, after having gleaned all that can be learned from books, in the first instance, it will be found impossible to acquire the knowledge thirsted after, without sections of mouldings, and forms which can be studied, properly, only in original buildings; as these forms are seldom to be met with large enough for practical art, in the numerous works with which the world is stocked. Architectural works, in fact, should be looked upon by the student as only the first step in his researches; as, notwithstanding the most careful and elaborate drawing which is bestowed upon their production (and which, as it is well calculated to lure the eye, and from the beautiful representations of buildings and general picturesque style which it displays, must tend much towards improvement in architectural taste,) the details are seldom sufficiently large to enable them to be as properly studied as in the original buildings. The want of this study may, in some measure, account for the deficiency in effect and correctness observed in the modern Gothic; general forms having only been considered by the architect, who, not having acquired a knowledge of the principles of detail, is driven to his own invention; and this generally creates a meagre and insipid design, seldom satisfactory to himself, and often held up to ridicule by others.

I do not mean that ancient architecture should be exactly copied in modern buildings, as this ought never to be the case, I merely recommend close study, that the spirit and feeling of the ancient artist may be understood, that a modern design may be in the spirit of the ancient style, though not in the actual style, and that the mouldings and mullions proper for one date may not be used in another. The architect should always bear in mind, that it is his duty, as it was considered by the architects of the middle ages to be theirs, to invent forms, and improve upon the architecture of by-gone days; yet still to follow the same general feeling, and to create a style perfectly distinct from any other known specimen, which shall be yet perfectly characteristic of the times and purposes for which it is intended. This is to be acquired only by the study of detail, as well as of general forms; and by a knowledge of the principles of the ancient architecture, of the forms belonging to the different periods, of the transitions from one style to another, of the nature of the materials, and of the manner of construction.

Architecture is generally considered one of the most important connecting links in the history of a country; and by the peculiarities of its style,

and its comparison with record, it affords us an interesting insight into the customs of earlier times. This being the case, it is much to be regretted that while our national museum contains some of the magnificent remains of Egyptian and Grecian art, so little regard should be paid to the remains of art in our own country, particularly at the present time, when Gothic architecture is making such rapid strides in the improvements in our cities. I have often thought, when it has been found necessary to take down an ancient building, that it was a public loss, inasmuch as the principal parts would be sold to the collectors of relics, and hidden forever, except to the chosen few. Instances of this kind are constantly occurring: ancient buildings are taken down, being considered either dangerous or inconvenient; the stone is sold, and the carvings, which have delighted and instructed many, are closeted for the benefit of one individual. This is much to be lamented, though it is at present, inevitable; but, if there were a national repository for some of the best selected of these carvings, they might be still a benefit to the world. Some time ago, the north-west tower of Canterbury Cathedral was taken down, and it is to be, or has been, rebuilt, to correspond with the other, which is of more recent date, although a very fine tower. What has become of the Norman remains of the ancient tower? Would it not have been desirable that some of the choicest fragments should be preserved in our national museum? not only as a record of that building, but as an example of early character. Many buildings are thus destroyed, and leave no trace behind, which might contribute considerably to the advancement of this style of architecture, if some of their fragments were preserved, and easy access could be had to them. At a small expense, a very perfect classification of Gothic architecture might be obtained; and, if well arranged, it would greatly tend to diffuse that taste and knowledge in architecture which is so requisite for the promotion of the art. These relics would be constantly before the eyes of the public, who would become familiarized with their forms and date; they would be considered as sacred and valuable records of the history of the art; and would insensibly lead to the preservation of ancient architecture, which has hitherto been so much neglected. It is even probable that churchwardens would catch a little of the infection, and would not suffer a fine building to be "repaired and beautified" by incompetent persons; which has too often been the case in many of our most beautiful buildings. The approaching competition for the Houses of Parliament will at least assist in improving the public taste: it will be the means of awakening the public attention to a style of architecture which raises so many agreeable associations in the mind of an Englishman. In contributing my aid to the illustration of the architecture of the middle ages, I do so with fear, at the same time that I consider it the duty of every architect to assist in promoting that general knowledge which is so essential to the advancement of art, and for the purpose of restraining the rude hands of ignorant men in power, from the spoliations which have been too often suffered by our ancient edifices. In this paper it is my intention to confine myself to a simple classification of the architecture of our own country, principally in the windows, as these are leading features in all our ancient building, and a general knowledge of their forms is a sufficient guide to the date of most other parts of the same building.

The oldest specimens of ancient architecture found in our own country may be probably dated as far back as the fifth century, and ascribed to the Romans (as here it will be unnecessary to mention those extraordinary

works commonly attributed to the ancient Druids;) and these only afford evidences of their authenticity from their mode of construction, as there are now I believe, no records remaining to throw a light upon the exact time of their foundation. The works in this style which are admitted by antiquaries to be genuine Roman works can be the only standard to refer to; and the similarity of other buildings to these will allow of conjecture as to their date. The nave of Brixworth Church, Northamptonshire, retains some of the characteristics of this style of architecture. The walls have recently, in part, been divested of their whitewash, which disfigured them, and the forms of the arches exposed: they are semi-circular, turned with bricks resembling those used by the Romans, and of various dimensions; sometimes in two rims, with a course of bricks laid flat between them, and on the outside rim the soffit of the arch raising quite plain, and at right angles to the face. Among other buildings supposed to be of this period are the remains of Richborough Castle, in Kent, and Jury Wall, Leicester. In many of the churches in Kent, Roman tiles or bricks, the remains of some arches, are still visible; though these remains may be merely the Roman materials brought from other buildings. In the tower of St. Alban's Abbey there is a window of two lights constructed with Roman bricks: in this example, the small pier between the arches may, perhaps, be considered as the prototype of the mullion of a subsequent period.

As the Anglo-Saxons were constantly involved in war, little time was given for the cultivation of the arts; but, about the time that Christianity was introduced in this country, many of the heathen temples were altered to the form required for the new religion. Some were entirely demolished, and Christian churches raised upon their foundations; but the successive invasions of the Danes, and the destruction they every where committed, have left us but few remains of this kind of architecture; and these few so much resemble the Norman style, that it requires the strongest presumptive evidence to assign a building to this period. The general forms were round arches, very few mouldings, massive columns, rudely carved ornaments and capitals, buildings generally upon a small scale, and frequently of unscientific construction. Parts of St. Alban's Abbey are probably of this date; Earls Barton Church, Barton upon Humbar, and some few others, are considered in this style.

The increased refinement in the manners of the Normans, their general love of pomp, and, above all, the comparative tranquility which succeeded to the Saxon sway, produced a new epoch in architecture; though the same general forms were used, the buildings were upon a larger scale, the mouldings were more complex, the ornaments were worked with greater exactness, and the whole improvements were such as would naturally arise from a progression of civilization.

This style is usually comprised between the years 1066 and 1189, which may also be divided into three periods. The first of these, the early style, immediately succeeded the Saxon, and retained many of its features, with very litte decoration: examples of this period may be seen in the nave of Rochester Cathedral, built by Gundulph, Bishop of Rochester, about 1077; the tower and other parts of Winchester Cathedral, built by Bishop Walkelyan, about 1080; the Chapel of the White Tower, London, about the same date; and at many other places. The middle period, or division, may be considered the most perfect of this style: the decorations were every where increased, and the chevron, the billet, label, embattled fret, indent, and nebule were among the decorations; the interlacing arches were also

profusely used. Examples of this division may be seen in St. Bartholomew's Church, Smithfield; South Ockendon Church, Essex; the Church of the Hospital of St. Cross, built by Henry de Blois, about 1136, &c. The third division may, perhaps, more properly be called the transition style, from its consisting partly of the perfect style, showing some of the general features of the next. In this division the pointed arch was frequently used; but the ornaments and mouldings retained the same character as in the last, though wrought with an increased complexity. In some instances the pointed arch appeared earlier, as in the Church of St. Cross: in fact, this church has almost all the varieties of the Norman style. The circular part of the Temple Church in London, and Becket's Crown, Canterbury Cathedral, are in this division: in Durham Cathedral there is also some transition work.

The semicircular arch is the characteristic of the Norman style; but in it the horseshoe, the Moorish, the elliptical, segmental, and pointed arches are sometimes to be met with. Windows with three lights, the centre one being raised considerably above the sides, are to be seen in Waltham Abbey, and several other buildings. In Little Snoring Church, Norfolk, is to be seen a semicircular arch within a pointed one, and these two are encompassed by another semicircular arch, with the sides continued from the springing to the impost. There are many examples where the pointed and semicircular arches are both used in the same place, which may be evidence of transition work. *Fig.* 1. is a section of the jamb mouldings of a window

Fig. 1.

Fig. 2.

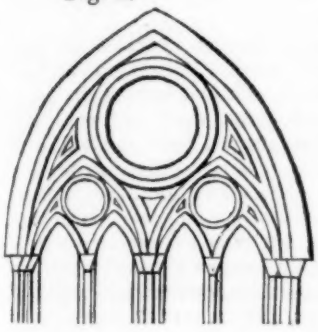
of the middle division. It will be seen by this section that the mouldings are geometrical figures, and are formed out of the flat surfaces of the arches: these arches form distinct recesses, and are very numerous in some buildings. From the peculiar character of the ornament, which, I believe, is always sunk, and never raised above the face of the stone, except in labels, strings, &c., I am inclined to think much of the ornamental work was carved when the arches were set; indeed, some unfinished work, occasionally to be met with strengthens this opinion. Cusps are sometimes found in the later divisions of this style.

The commencement of the reign of Richard I. (1189) is the period usually assigned for the general adoption of the pointed arch, and from the decided change from the massive proportions of the preceding periods to the lofty proportions of the Gothic style, and to that general tendency to perpendicular lines, instead of horizontal ones, which characterised it. Of the numerous names applied to this style of architecture each has its merit in some peculiar way, though but few can be allowed to be sufficiently compre-

hensive: under these circumstances, I will not presume to add to the catalogue of titles by which it is designated, but shall content myself with the term Gothic, which is generally applied, commonly accepted, and always understood to signify that light and elegant architecture which became general after the Norman style, and which was characterised by the use of the pointed arch and perpendicular lines, as, when so applied, its barbarous definition is never thought of.

The Gothic style may be divided into four classes: viz. 1st Class, which is composed of geometrical forms, in circles and segments of circles, with equilateral and lancet arches; 2d Class, with ramified tracery, sometimes resembling the fibres of leaves, and equilateral lancet arches; 3d Class, with perpendicular lines, and compound arches; 4th Class, also, with perpendicular lines, and compound arches continued, but increased in richness and the number of mouldings; the general proportions being, consequently, more heavy in appearance.

Fig. 3.



The First Class of Gothic Architecture, commenced in 1189, and continued till about 1272; and in the first division of this class many of the mouldings and ornaments retained some of the characteristics of the Norman style; while among its principal decorations, slender marble columns, highly polished, appear very conspicuously. These columns were introduced perfectly unconnected, except by the capital and base, and were frequently carried to a great height. Where they remain in our buildings in their original state, they produce, by their richness, a beautiful contrast to the plain stone. The square recesses of the Norman style were now changed to plain splays, chiefly in the exteriors, though the interior mouldings were still governed by the same general principles. *Fig.* 2, is a section of the arch mouldings of the east window in the north aisle of Stone Church, Kent, which will show the character of the mouldings of the middle division of this class; and their distinctive marks will be seen by a comparison with those in *Fig.* 1. The degree of progress obtained in the mouldings of this period will also be seen; and by again comparing the section, *Fig.* 2, with the elevation *Fig.* 3, something of the same geometrical character will be observed. *Fig.* 4, is a section of the window jamb, or

Fig. 4.

Fig. 5.

Fig. 6.

architrave, below the springing of the arch, which more distinctly shows the splaybefore alluded to: it will be proper to mention that this section is not taken from the same window as the other, as that could not be obtained, in consequence of the lower part being entirely enclosed with brickwork and plaster. In this, (*Fig.* 4.) which is from a window of two lights in the same church, are shown two isolated marble columns. *Fig.* 5, is the section of the exterior jamb moulding of the same window. *Fig.* 6, is another specimen of an exterior architrave and label moulding from Rochester Cathedral. *Fig.* 7, is a section of an exterior jamb moulding and mullion, of the first division of this class, from Rochester Cathedral.

The middle division of the first class of Gothic architecture had scarcely reached its highest point of beauty when it began to decline: and, first, the slender lofty marble column, which had been, from inexperience, formed of marble the laminæ of which were perpendicular instead of being horizontal, split into several pieces, from the weight it had to support; and, consequently, a substitute for this was rendered necessary. This was found by connecting the columns to the mullions in the last division of this style, and by running them up in smaller piers of freestone. The marble column thus gradually got into disuse; and this will account for the decay of many of our early Gothic buildings, and for the necessity, in the next class, of putting in new windows. In buildings of this period, it is not an uncommon thing to see capitals and bases without the shaft of the column. Here, we may reasonably suppose, once stood a marble shaft, which probably split and fell, though bearing little more than its own weight. In the early division of this class, few cusps were introduced into the window heads, and these were only in the perfect figures of the upper parts. Examples of this first division may be seen in Barnes Church, Surrey; Rochester Cathedral, &c.; and of the middle division, in Westminster Abby, about 1245; Wells Cathedral, 1220; and in the east end of New Shoreham Church, Essex, 1220. Stone Church, Kent, is of this division; and in this church, which is one of the most perfect specimens of this class of Gothic architecture, it is curious to observe the increase of richness in the architecture as you proceed from west to east: this practice, which is, I believe, to be seen in all our ecclesiastical edifices, is, in this one very conspicuous. Of the third, or transition, period, some examples are to be seen in Little Maplestead Church. The characteristic arches of this class are the equilateral and the drop arch, with occasionally the lancet specimens of windows. The toothed ornament was much used in this class, in the hollow mouldings; beautiful specimens of which may be seen in Stone Church, and in the arch leading to St. Bartholomew's Church, Smithfield; and also in the restored Lady's Chapel, Southwark.

Fig. 7.

The Second Class of Gothic Architecture commenced about 1272, and continued to 1377. The fault discovered in the marble columns of the preceding class was the means of their disuse; and their places soon became supplied with mullions formed of the same moulding as the tracery mullion; and the geometrical figures of the window heads of the

Fig. 8.

last class were, by slow degrees, made to take the undulating form which belongs to this class. *Fig.* 8, will show the probable origin of this style. In the first division of it, the tracery and mullions were of the simplest kind, and seldom exceeded a hollow or splay and fillet, both inside and outside: but the fertile genius of the ancient architecture soon produced improved forms; and the windows of the middle division of this class are justly celebrated for their elegance of contour and diversity of design; much of the tracery resembling in the outline the fibres of leaves. Sections of the jamb mouldings are shown in *Fig.* 10. In this section the splayed jamb shows very distinctly that the hollows are remains of the last style; but the mullion is very different. As I have endeavored to point out, in the other class, the connexion in character between the section of the mouldings and the window heads, here I will again mention this circumstance. The sections of the mouldings, *Fig.* 9, are of a less abrupt and geometrical style than those of the first class; and they partake of the easy flowing lines which are conspicuous in the tracery, and which in both are perfectly distinct from the other class. Thus it will be observed, that the ancient architects, when they diverged from the general compositions of their predecessors, retained the same spirit in the new designs; for when the change of circumstances necessarily produced a change in the buildings, the spirit of fitness and propriety was still adhered to.

Fig. 9.

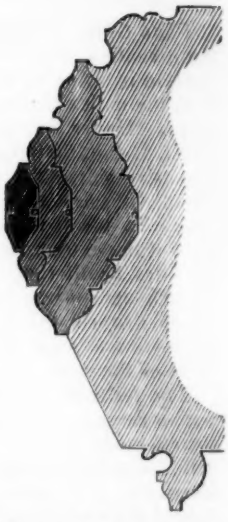


Fig. 10.

The characteristic arch of this is the equilateral; and the bulb ornament, or ball flower, frequently used in the architrave, or jamb mouldings, belongs to this period: it consists of three leaves clasping a kind of round petal. In some windows this ornament is carried round the hollow of the mullions and tracery, as at Gloucester Cathedral. Examples of the first division of this class may be seen in the organ screen in Canterbury Cathedral, 1304; St. Peter's Church in the Tower of London; Chapel of St. Stephen, Westminster, about 1330, &c. Examples of the middle division of this class will be found in the spire of Salisbury Cathedral, parts of Rochester Cathedral, and in many of the churches at Oxford; and in most of which buildings there are also examples of the last, or transition, division, which may also be seen in the west end of Gloucester Cathedral.

(TO BE CONTINUED.)

Mechanics' Register.

Plate Glass. The casting of plate-glass has, since the first discovery of the invention, been an inportant branch of French manufacture. The invention is owing to Abraham Thevart, who, in the year 1688, introduced it to the notice of the French administration, and received due encouragement. Under their protection and assistance, the manufactory at the Castle of St. Gobin, three leagues from Laon, was established. This is the most extensive plate-glass foundry in France; it has gradually increased in its number of furnaces, fages, and appendages, until it now presents the appearance of a town, rather than a manufactory. A plate has been lately cast here of the extraordinary dimensions of fifteen feet by twelve, for the Château des Thuilleries. British plates are now equal in quality to the best French specimens, but they are more subject to a degree of undulation, which distorts the appearance of objects: this defect is probably owing to the mass not being continued in a sufficient state of fusion, during the progress of the operation of casting. Lond. Jour. of Arts.

The Ice trade between America and India. The arrival of the Tuscany with a cargo of ice from America, forms an epoch in the history of Calcutta. So effectual was the non-conducting power of the ice-house on board, that a thermometer placed on it did not differ perceptibly from one in the cabin. From the temperature of the water pumped out, and that of the air in the run of the vessel, Mr. Dixwell ascertained that the temperature of the hold was not sensibly affected by the ice. Upon leaving the tropic, and running rapidly into higher latitudes, it retained its heat for some time; but after being several weeks in high latitudes, and becoming cooled to the temperature of the external air and sea, it took more than ten days in the tropics before the hold was heated again to the tropical standard. Asiatic Jour.

First Tunnel under the bed of a navigable river. This tunnel has been successfully made under the stream of Black Water, at Waymouth. The river has thirteen feet of water at high tide, and seven at low. The tunnel, so called, is intended for the passage of a main gas pipe, and is seven feet high by four and a half wide. Its length is upwards of four hundred and fifty feet. Abstract Rep. Pat. Invent.

British Institution of Civil Engineers. This Institution which now numbers seventeen years since its origin, is about to publish its transactions. The publication has grown out of their weekly meetings for conversation on business connected with the profession. Ibid

Access to the Cornish mines. This is had by nearly vertical ladders interrupted at intervals by platforms. In issuing from the depth of from twelve to fifteen hundred feet the miner occupies more than one hour, and on a moderate estimate, it has been calculated, expends one fifth of his force in going to and returning from work. Ann. Rep. Cornwall Plytech. Soc.

Spider Silk. In France, M. Bon has had gloves and stockings manufactured from the spider's cocoon.

Cause of the earthquakes in the Ionian Islands. Doctor Davy finds an adequate cause for those in the access of water to the calcareous marl deposits of those engines. The marl swells when water is thrown upon it. In Aphalonia, there is a remarkable case of four descending streams of sea water, which disappeared below the surface. The subjacent strata are of the kind referred to above. An ingenious Englishman has put one of these streams to practical profit, by establishing a grist mill on its site.

Jameson's Journal.

Patent Caoutchouc Cloth. A case of considerable interest arising under the patent of Messrs. Mackintosh & Co. of Glasgow, for water cloaks, has recently been decided in the Court of Common Pleas, London, before the Chief Justice and a jury. The verdict was for the plaintiffs, Messrs. Mackintosh & Co. Lond. Mech. Mag.

List of American Patents which issued in May, 1836.

		May.
332.	*Feather dressing.*—B. S. A. Todd, Marietta, Ohio.	6
333.	*Flyer for spinning.*—Samuel Ladd, Waltham, Mass.	6
334.	*Pump.*—J. F. Walther, Easton, Penn.	6
335.	*Balance.*—Jirah Vaughan, Rutland, Va.	6
336.	*Cutting vegetables.*—Austin H. Robbins, Denmark, N. Y.	6
337.	*Horse power.*—Amos Adams, Augusta, Maine.	6
338.	*Botanic medicine.*—Samuel Thompson, Boston, Mass.	6
339.	*Shoe making machine.*—James Hall, North Bridgewater,	6
340.	*Thrashing and shelling machine.*—Nicholas Goldsborough, Easton, Md.	6
341.	*Raising water.*—Joseph Turner, Poland, Maine,	6
342.	*Thrashing machine.*—George Beaumont, Mount Pleasant, Penn.	6
343.	*Stove.*—Nathaniel Russel, Waterville, Maine,	14
344.	*Canal lock indicator.*—Valentine Brown, Clifton Park, N. Y.	14
345.	*Canal lock gate.*—Valentine Brown, Clifton Park, N. Y.	14
346.	*Water, applying.*—J. Hinds, M. B. Ball, and S. Pike, Troy, N. Y.	14
347.	*Sawing machine.*—Joseph Peevy, Levant, Maine,	14
348.	*Washing machine.*—L. R. Prince, Beverly, Mass.	14
349.	*Pearl ashes.*—J. and N. Parce, Linckland, N. Y.	14
350.	*Distilling, cold.*—A. V. H. Webb, Utica, N. Y.	14
351.	*Canal lock.*—David Wilkinson, Cahoes, N. Y.	14
352.	*Plane.*—John T. Jones, Philadelphia,	14
353.	*Grate.*—James Bennett, New York,	14
354.	*Horse power.*—Isaac Straub, Lewistown, Penn.	14
355.	*Saw mill.*—W. J. McGhee, Columbus, Geo.	14
356.	*Sawing timber.*—Joshua Webb, Brooklin, Conn.	14
357.	*Cannon traverse board.*—Wm. H. Bell, Washington, D. C.	14
358.	*Spinning machine.*—John Morgan, Manyunk, Penn.	14
359.	*Mill wheel.*—S. H. Freeman, Cecilton, Md.	17
360.	*Platform balance.*—C. P. Ladd, Irasburg, Vermont,	17
361.	*Horse rake.*—Erastus S. Root, Mount Morris, New York,	17
362.	*Brooms and brushes.*—Thos. Kinsley, Cabotville, Mass.	17
363.	*Regulating machinery.*—Nathan Scholfield, Norwich, Conn.	17
364.	*Butt Hinges.*—Jonas Rouse, Troy, N. Y.	17
365.	*Cider mill.*—Elias Jenkins, Harmony, Penn.	17
366.	*Platform balance.*—Jas. M. Peck, Syndon, Vermont,	23
367.	*Kitchen range.*—Geo. Johnson, Philadelphia,	23
368.	*Clock spring.*—Joseph S. Ives, Bristol, Conn.	23
369.	*Horse power.*—C. Custer and D. Pennypacker, Upper Providence, Penn.	23
370.	*Cart and carriage wheels.*—William Woodbridge, Kennebec, Maine,	23
371.	*Steam engine.*—A. S. Dawley, Boston, Mass.	23
372.	*Spark extinguisher.*—A. Whitney and S. S. Burr, Albany, N. Y.	23
373.	*Locks.*—P. B. Quimby, Belfast, Maine,	23
374.	*Feather dresser.*—George Reynolds, East Hartford, Conn.	23
375.	*Timber, slitting.*—R. Beale and M. Bucklin, Grafton, N. H.	23
376.	*Building stores, &c.*—Isaac Knight, Baltimore, Md.	23
377.	*Tanning.*—Simeon Heath, Pike, N. Y.	23
378.	*Water wheel.*—William Hitchcock, Spencer, N. Y.	23
379.	*Reed making machine.*—J. A. Wilkinson, Providence, R. Island,	23

CELESTIAL PHENOMENA, FOR SEPTEMBER, 1836.

Calculated by S. C. Walker.

Day.	H'r.	Min.						
5	14	56	Im	c	Geminorum	,6,	101°	47°
5	16	1	Em				264	206
20	9	19	Im	m	Capricorni	,6,	95	104
20	10	31	Em				314	336
22	11	20	N. App. Dand σ^2 Aquarie, 5.6, ☽ N. 3.'5					

Meteorological Observations for May, 1836.

Moon.	Days.	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inches	Inches			Inches.	
☉	1	44°	70°	30.24	30.20	W.	Moderate.		Clear day.
	2	58	81	30.00	30.00	SW.	Brez ze.		Clear day.
	3	64	83	29.70	29.70	S. W.	do.		Cloudy—partially cloudy.
	4	67	74	29.70	29.60	N.W.	do.		Lightly cloudy,
	5	48	72	30.00	30.00	N.	do.		Clear day.
	6	42	74	29.96	30.00	W.	do.		Lightly cloudy—clear.
☽	7	53	66	29.85	29.60	E. SW.	Moderate.		Rain—Cloudy.
	8	55	66	29.76	29.86	N.	do.		Cloudy—lightly cloudy, aurora B.
	9	46	66	30.00	30.06	NNE.	do.		Clear day.
	10	42	74	29.90	30.16	S.	do.		Clear day.
	11	48	78	30.04	30.19	SWS.	do.		Lightly cloudy.
	12	58	78	29.70	29.60	E. S.	do.		Partially cloudy.
	13	64	65	29.50	29.70	NW.	do.		Lightly cloudy.
	14	34	69	30.30	30.34	NW. S.	Brisk.		Partially cloudy.
	15	42	69	30.24	30.30	E. W.	do.		Clear—Sn eet'd—clear, very dry
	16	52	80	30.05	30.00	S. W.	Moderate.	.4	Lightly cloudy—clear—shower.
	17	61	82	29.90	29.90	W.	do.		Clear—lightly cloudy.
	18	60	88	29.90	29.90	WSW.	do.		Clear—floating clouds.
	19	59	79	30.07	30.07	NW. W.	do.		Clear—floating clouds.
	20	54	80	30.10	30.10	S. SSW.	Brisk.		Clear—lightly cloudy.
	21	64	90	29.90	29.82	W.	do.		Lightly cloudy.
	22	66	86	29.85	29.84	W.	do.		Clear—flying clouds.
	23	64	84	29.70	29.70	S. W.	Moderate.		Clear—flying clouds.
	24	66	64	29.70	29.70	S. E.	Brisk.		Clear day.
	25	53	68	29.65	29.65	SE.	Moderate.	.5	Drizzle—cloudy.
	26	54	64	29.83	29.90	SE.	Brisk.		Cloudy—rains in night.
	27	47	51	30.00	30.00	E.	Moderate.	.23	Drizzle—rain—cloudy.
	28	49	67	29.86	29.83	NE.	do.		Drizzle—cloudy.
	29	62	62	29.80	29.83	SE.	Brisk.	1.30	Drizzle—rain in night.
	30	48	52	29.86	29.90	E.	do.	.8	Drizzle—cloudy.
	31	54	54	29.95	29.95	NE.	do.		Cloudy—cloudy.
	Mean	53.84	72.03	29.90	29.90			1.62	

	Thermometer.	Barometer.
Maximum height during the month.	90, on 21st.	30.24 on 1st, 14th. 15th.
Minimum do.	39. on 14th.	29.50 on 13th.
Mean do.	62.93	29.90